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GEOLOGICAL NOTES OF IRELAND.

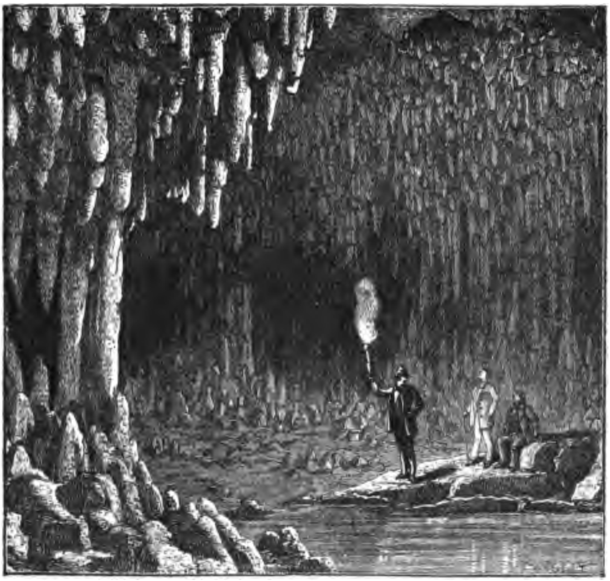
WITH THE LOCALITIES OF ITS MARBLE, STONE, AND MINING
DISTRICTS.

ALSO ITS

NATURAL WONDERS.

AND REMARKS UPON THE PRESENT AND FORMER CONDITIONS
OF THE EARTH.

With an Addenda.



CAVERNS OF MITCHELSTOWN.

By WILLIAM HUGHES.

Fourth Edition.

REVISED, ENLARGED, AND WITH NUMEROUS ILLUSTRATIONS.

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TO

The Right Honourable Lord Viscount Powerscourt,

THE UNTIRING

AND ZEALOUS PATRON OF IRISH ART AND

IRISH PRODUCTS,

The Fourth Edition

OF THIS BOOK, STILL FURTHER REVISED,

IS,

BY HIS LORDSHIP'S GRACIOUS PERMISSION,

MOST RESPECTFULLY DEDICATED

BY

THE AUTHOR.

TO

SIR ROBERT KANE, LL.D., F.R.S.

COMMISSIONER OF NATIONAL EDUCATION,

WHOSE INVALUABLE LABOURS,

THE "INDUSTRIAL RESOURCES OF IRELAND," HAVE LARGELY

CONTRIBUTED TO THE PRODUCTION OF THESE

CHAPTERS,

This Third Edition,

REVISED AND ENLARGED,

IS,

WITH KIND PERMISSION, MOST RESPECTFULLY

DEDICATED

BY

THE AUTHOR

INTRODUCTION.

IN revising and reprinting this book I have made several important changes, and considerable additions. It has been almost rewritten, and I have, to some extent, divested it of its exclusively professional character, and added a few explanatory illustrations. I have been influenced in this by its previous unprecedented success; and when informed by my publishers that the former editions were exhausted, or what is usually called "out of print," I considered it better it should appear in more attractive form, in order to induce a still more numerous class of readers than geology in its ordinary technical mode is likely to encourage; and I have no doubt, when thus presented, with very many it will become an introductory guide to a most pleasing and instructive study.

To the traveller and the tourist, who have made acquaintance with it in its most initiatory forms, it cannot fail to prove interesting, as recalling to mind, at a single glance of the surrounding scenery through which business or pleasure may lead them, the geological formation of the country through which they pass. The serrated peak, the conical summit, the tabular, stair-like mountain, the precipitous cliff, the undulating plain, all tell their own tale, leading the mind insensibly back to periods and ages of indefinite time, long and long before man existed upon this earth; and to explain all this is my present purpose.

Ireland is peculiarly fortunate in this respect, as containing within it examples of almost every known formation; and to this we are indebted for the varied scenic panorama which presents itself to the eye generally throughout the island. And, although in writing the former editions it was more my intention to devote them entirely to simple explanatory notes, I am egotistical enough to imagine this revised one may prove perhaps of more interest to the general reader. For the uninitiated, then, this book is again produced as a pioneer, to learn, from standard authors as well as nature's page, one of the most interesting of sciences; and it is to be hoped that those who have studied in its higher walks will not look unfavourably upon my attempt to simplify its teachings.

I have added an Addenda, explaining the causes which produce disintegration of rock, the antiquity of this earth, the climatic changes it has been subjected to, the supposed antiquity of the human race, and finally, the igneous condition of the centre of our globe, all of which are necessary adjuncts to the study of geology, and which, I trust, may repay a perusal.

WILLIAM HUGHES.

Talbot-street, Dublin.

PREFACE TO THIRD EDITION.

UNTIL a recent date geology has been a sealed book, the knowledge of which was attainable only by the few, scientific terms so much abounded in its teachings, and given in bulky volumes, as to render it unapproachable by the many. To begin from the beginning, and to adopt a plain and concise mode of conveying information upon its most salient points shall be my endeavour, which, I trust, will be appreciated by those for whom the following pages are intended.

The demand for the first and second editions of this book have considerably exceeded my anticipations; possibly, this may be accounted for by the favourable opinions expressed towards it by all sections of the press throughout Ireland, whether deservedly or not. I am, therefore, induced again to reproduce it with considerable additions; and in order to render it more complete, and the more familiarly to explain the origin of all mineral formations, I think it necessary to refer to the condition of the earth previous to the creation of man, as, beginning from this source, the rudiments of geology are with greater facility rendered intelligible to those previously unacquainted with it.

Before proceeding to this I would remark that up to, and even in the beginning of the present century, there were people who imagined that stones grew. Their classification had not then even been attempted by the learned in lithology either in England, France, or Germany. Men of science asserted there was life in stone, and that they could be cultivated like vegetable products if they could only ascertain the germs which originated them; however, the researches of the modern school dissipated all these monstrous absurdities,* and we have begun to learn that, although the English language is wanting in expression, the divisions and subdivisions of the igneous and aqueous formations of the earth by words of Greek derivation is not sufficient to scare the general public from investigations of the science.†

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* Everyone knows that Voltaire's opinions were invariably ridicule of Scripture, and that his every idea was prejudiced from this cause. All his ingenuity was employed to oppose the Mosaic account of the

The eruption of volcanic matter, the cooling down and subsidence thereof, the wearing away by the action of the atmosphere of the primary rocks, and the deposition of their *debris* under water, forming what is known as Sedimentary Rock, is perhaps sufficiently explained in the following chapters, and needs no special reference here;

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creation and the deluge; for instance, he asserts that the shells discovered in Alpine regions are simply freaks of nature, or else they were carried thither by pilgrims from Syria; therefore, so much for the opinions of men of science of the last century.

† "Towards the close of the eighteenth century Pallas and Saussure were the first who formed the idea of distinguishing the mineral masses of our globe, and separating them into groups." Lyell's "Geology," vol. i., chap. iii., page 61. Werner, at an earlier period, invented the terms, "grauwacke," "gneiss," and others, from his native German, and these names still pass current. Smith, 1790, affixed Anglo-Saxon provincial terms to several formations, as "gault," "cornbrash," &c.; but it remained for the Geological Society of London, founded 1807, to become the pioneer of the present system of classification of rock. The nomenclature of the later systems is due to Sir Charles Lyell, as eocene, miocene, pliocene, and post-pliocene, all compounded of Greek words, signifying "earliest new," "less new," "more new," and "often more new."

therefore, I will only direct attention to the fact, that this planet has existed for indefinite time, long and long before the human race was called into existence; and although, to some, the theory may appear not in accordance with Scripture, it on the contrary compels us the more fully to believe in it, and the more to reverence the power of that Divine Being who, through successive changes of this earth's surface, at length fitted it as the abode of his image, man.

These teachings many will consider not strictly orthodox, but it is to be remembered the simple scriptural account of the creation was written not for the scientific but for the ordinary conception of the human race, and that it was altogether needless to inform them what previous changes had taken place in the world they were formed for. The six days of the first chapter of the Book of Genesis may or may not be figurative, for it was equally in the power of Him who created all things to renovate the earth and its surroundings in hours much less in days; there are limits to all human knowledge, and this is one: the mind of man cannot grasp what is sealed from him by his Maker.

The stupendous works of the ancient Egyptians, their excavations for foundations of pyramids, their temples, their canals and tanks, their quarrying for the different materials used in the construction thereof, as also for their monoliths, afforded them facilities for geological information of which few nations or peoples have had opportunity; hence, it is not surprising they early became acquainted with the previous conditions of the earth. In modern works—railway cuttings, tunnelling, and mining explorations—far greater depths than the ancients ever contemplated have been arrived at, and have afforded much more extensive information than they obtained; still it is singular that the discoveries of the present day are only confirmations of what has been taught considerably over two thousand years ago.

Egyptian cosnogony* was adopted by the Greeks, and engrafted upon the "Institutes of Menù," the sacred volume of the Hindoos; but perhaps the information of the latter was more particularly derived from traditionary accounts of the deluge and the volcanic eruptions occasionally desolating parts of Asia.

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* "Prichard's Egypt. Mythol.," page 177.

That the age of the earth dates back so far into infinite existence as to seem to those who have studied its history an eternity of the past, is agreed; and also that it was in its earlier periods the theatre of teeming life, both vegetable and animal, over and over again renewed through successive terms of destruction and renovation, records of which are inscribed in indelible characters in the vast catacombs of fossil remains which present themselves to the view of the geologist; while its flora and fauna, varying with each of these phases of its history, yet preserved so plainly, and presenting so faithfully lines of demarcation drawn between them as to make easily discoverable their different periods of existence; while a retrospect of the time illimitable, necessary to produce them, not only teaches but fully confirms the theory above given.

Thus it has been discovered that, previous to the creation of man, this earth, as mentioned in the following pages, was subjected to repeated changes, that thousands of years intervened between them, and that each completely destroyed all vegetable and animal life, or, as geology calls it, "the flora and fauna" of former periods, that glacial and tropical periods intervened, until at length Divine

Wisdom fitted it for an abode, and created for it man.

It is ascertained with the greatest approach to probability, if not with exact certainty, that, since vegetable and animal life has existed, at least twenty-nine different destructions and reorganisations of the earth's surface have taken place, which consequently made various changes in the distribution of land and water: what was land in one geological age became the beds of seas in another, and *vice versá;* and to this we are indebted for being enabled to prove the former duration of the earth, and also to tell that four great convulsions preceded the introduction of life on the surface of this globe.

The vast intervals of time which elapsed between each destruction of the earth's surface and its renovation are divided into six different periods, or ages (which farther on are described at greater length), thus: Azoic, Palæozoic, Triassic, Jurassic, Cretaceous, and Tertiary, which are again subdivided into stages, and these stages contain the successive depositions of the mineral strata deposited during their periods.

The first, Azoic, as its name implies, is wholly destitute of all traces of organic life, and contains several groups of strata resting upon the igneous rocks, therefore it is concluded this formation was produced before life in any form existed upon the earth.

The second is called Palæozoic, in which the first traces of organic life in fossil remains appear; and in this five distinct stages, each containing different deposits, showing widely different ages of existence, and different types of "flora and fauna" from those which preceded them.

In like manner the Triassic consists of two such stages, the Jurassic of ten, the Cretaceous of seven, and the Tertiary of five, making twenty-nine in all, each of these representing so many different renovations of the surface of the earth.

In the following pages I have confined myself, in a great measure, to the original and great natural divisions of rock—as granite, slate, sandstone, limestone, lava, and trap, all of which are subdivided into numerous varieties, either according to their contact with igneous matter, or from the age of their deposition, or the names of the localities where they most abundantly occur, but all these different groups are comprised in one or other of these stages, and it is apparent that long periods intervened between their several formations, and also that all sedimentary rocks must have been, age after age, either the bed of the ocean, or of lacustrine formation, at one time upraised and forming dry land, at another depressed and covered over by waters, and this process repeated again and again at various periods. Veins of igneous rock have violently protruded through them, sometimes forming conical and peak-like summits, or poured over them in tabular masses, thus accounting for the change of structure and total loss of all traces of stratification in many.* These protrusions, where occurring with more than ordinary violence, have uplifted the strata overlying them, and formed the great mountain ranges of the globe, displacing the waters and producing new ocean-beds, where previously had been dry land, destroying life in every form wherever their influences reached; and it is to be supposed—and is certainly within the bounds of probability—that, when man's period shall have been fulfilled, similar agencies will again destroy the earth, and, perhaps, the Creator of all things will again repeople it with another race as far superior to man as he is to the baboon and ape who preceded him in former conditions and ages of its existence. For it has been thus throughout all time: the inferior orders of creation were the first called into existence; new orders, age after age, succeeded them, each with more highly developed powers; and as Scripture teaches this world of ours (of whose previous history we could form no conception except through geological discoveries) will be destroyed, it is no stretch of imagination, judging from analogies of the past, to think that it will again be the scene of life of far higher organisation than we can form ideas of.

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* These are called metamorphic rocks, by which name all deposits coming into immediate contact with igneous rocks are known. The name is derived from two Greek words, signifying trans-form, because in these instances the entire nature of sedimentary rocks are altered and they have been made to assume, sometimes dark and sometimes lustrous colours, and new substances are either engendered or introduced as talc, mica, &c., into their texture, and in this way the talcose and micaceous schists have been formed.

WILLIAM HUGHES.

NOTE.

In referring to the creation of the world in the preceding, I have stated, "the six days of the first chapter of the Book of Genesis may or may not be figurative;" however, it might be, days in this instance are not used exactly in their literal meaning, and could be interpreted as periods. There was a tradition extant amongst the Jews that, as the world was created in six days, and a rest appointed for the seventh, so it was intended by its Creator to last for 6,000 years, after which it should enjoy a rest of 1,000 years under the reign of the Messiah.

Many texts of Scripture tend to confirm this tradition; but with regard to the interpretation of the word "days," perhaps the most remarkable example is the following:—

"But of one thing be not ignorant, my beloved, that one day with the Lord is as a thousand years, and a thousand years as one day."—2 Peter, iii. 8.

PREFATORY NOTE TO FOURTH EDITION.

THE truly patriotic remarks of a distinguished nobleman, one of Ireland's truest friends, at the recent distribution of prizes by the Art Union of Ireland, has considerably influenced the issue of a fourth edition of this book, which, originally written for the purpose of affording information upon the localities of the mineral resources of Ireland, has in each succeeding edition entered upon a wider field and developed itself in more attractive form in the endeavour to familiarise the reader (by homeopathic treatment of scientific teaching) with the general formation of his native country and of the entire globe; an unpretentious title has been adopted the more to induce the general public and strangers to the country to follow its pages; however its object, the encouragement of the use of Irish marbles and stone, which are so abundantly distributed throughout the country, remains unchanged. It is, perhaps, a melancholy reflection to witness the constant importation of continental marbles and continental and English stone in a country abounding with both; except for statuary purposes, the marbles of Ireland are not excelled throughout the entire world, while the excellence and the varieties of its granite, limestone, and sandstone are proverbial: and, further, the black marbles of Lough Corrib are constantly imported into England and Scotland, and even into the United States of America. Whether the more general use of these materials at home is caused by apathy or lack of information it is not the author's purpose to determine; if it be the latter, the mission of this book is devoted to the remedy, for it is too true that, perhaps, from want of knowledge imported material is frequently preferred to the more enduring native products. Quite recently an ornamental fountain of Cornish granite has been erected outside St. Stephen's Green Park, Dublin, by an Irish lady, and within a few miles of the quarries of a similar tinted but more durable stone, and one susceptible of an equally high polish. Numerous like instances occur in every part of Ireland; but the allusion of the noble lord above mentioned with regard to Mucross House, faced with imported oolite, pervious to every shower, in a district whose surroundings are all of the finest description of limestone, to which age imparts the very tint of the imported stone, but, unlike it, incapable of allowing the wildest whirlwind of rain to permeate through it, exceeds them all, and needs no comment; and if the humble efforts of the author of this little volume tend even in some degree to remedy this state of things his most sanguine wishes will be realised.

ERRATA.

Page 5, line 18,	*for*	"cosnogony"	*read*	"cosmogony."
Page 64, line 2,	"	"trappena"	"	"trapean."
Page 127, line 5,	"	"fossilized"	"	"fossil."

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AND

GEOLOGICAL NOTES OF IRELAND.

CHAPTER I.

Preliminary Remarks—Water and Ice—Strata—Theory of the Origin of Igneous Rocks—Deposition of Sedimentary Strata—Distribution of Stone.

THAT this island of ours has been subjected to numerous and violent changes of its surface during ages and ages of by-gone time is fully admitted by all authorities. The restless ocean wave and the gigantic billows of the Atlantic have rolled and foamed for more than one period and for immeasurably long ages over its greatest heights. The volcanic forces of the earth have, on numerous occasions, exerted their producing and destroying influences. The desolating mantle of the polar regions has, over and over again, enveloped it in icy covering, while at intervals, tropical summer pervaded it from north to south and from east to west. A temperate clime at length prevailed, and finally it began to assume something like its present varied and picturesque aspect; for this we are wholly indebted to the denuding influences of water, whether in the form of river torrents, ocean waves, snow, or ice. Water, in its congealed state, has left its imprint even to this day on the summits and declivities of our highest mountains, where bold bluffs have, in very numerous instances, been ground down and polished into smooth surfaces, which still glitter in the broad sheen of the noonday sun; in others, grooved, scored, and striated, they remain faithful and unerring records of their own past history: many of their tops have been sculptured into dome-like shapes, then rain has mellowed and softened down their original rude outline. Titanic masses of rock have been transported more than a thousand feet above the sea level, and similar blocks lie scattered broadcast over the valleys and the plains, and sometimes embedded profusely in the soil. Inland seas, deep gorges, river beds, and picturesque caverns, have been hollowed out by the same influences; estuaries and arms of the sea, wildly beautiful overhanging cliffs and pinnacled rocks, have been formed by the furious onslaught of the impetuous wave. Therefore it is to the agency of water we must attribute all the scenic attractions of which Ireland may well boast; but for its general outline, its petrological and argillaceous forms, we are indebted to the successive changes it has undergone during an infinity of time, and which we have entered into more fully with regard to Ireland, and the earth generally, in accompanying Addenda, in order that the first principles of Geology may be made easily intelligible, as it is solely for the uninitiated inquirer these pages have been written; but while they profess principally to treat upon the general formation and localities of Irish mineral resources, it is to be hoped that the information they convey may prove interesting to all who are anxious to become acquainted with the first rudiments of one of the most instructive and useful of sciences as well as the main geological features of Ireland; for, after all, this study has but one tale to tell to those who wish to learn the history of the earth—its teachings being, in the main, uniform over the entire globe—yet there are differences, but only as regarding greater volcanic influences—in one region more than another; still, each and all are but exponents of the infinite power and majesty of Him who has created our little sphere and its gorgeous surroundings.

To examine a section of country in which its formation can be readily explained, is not often possible. True it is we have in the gorges of mountain torrents and in the cliffs of mountains sectional areas laid bare of greater or less magnitude; but these are generally so overgrown with tangled brushwood and fern as to be undistinguishable, except to the practical geologist.

In railway cuttings we have examples (although upon a small scale) of beds of different strata occasionally disposed horizontally, but generally inclined, in consequence of primitive rocks protruding through them. If it were practicable to arrive at a sectional cutting of the surface of a country which had never been disturbed, we would find it in the following order :—First, mould at the surface ; below it, beds of clay of varying thickness and tenacity, sometimes interspersed with boulders; then sand and gravel; underneath which, stratified rock; and, beneath all, the primitive or igneous rocks. But a horizontal section like this could not be, from the constitution of the earth. The primitive rocks we generally find at the surface and in most elevated positions. Modern Geology teaches us that this globe of ours was once a fluid mass in a state of igneous fusion, in which condition its centre still continues. At the period which this refers to, portions of its interior were propelled to its surface as they now are by volcanic action, which, by degrees, gradually cooled down and formed themselves into a crust, of which granite and the other igneous rocks are the representatives, and when cooled down, that by condensation of the surrounding atmosphere, it became one vast ocean. Convulsion upon convulsion followed, by which mountain and dry land were reared over the surface of the waters; and, if this be correct,* we must

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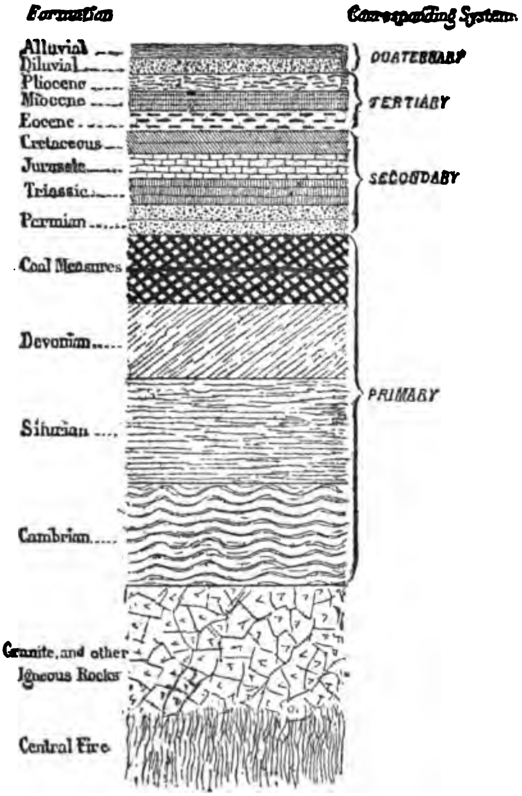
* Scripture teaches this theory thus: "And the earth was void and empty, and darkness was upon the face of the deep; and the Spirit of God moved over the waters" (Gen. i. 2). "God also said: Let the waters that are under the heavens be gathered together in one place: and let dry land appear. And it was so done" (Gen. i. 9).

Section of the Terrestrial Crust, Showing the Different Formations from the MOST RECENT TO THE MOST ANCIENT

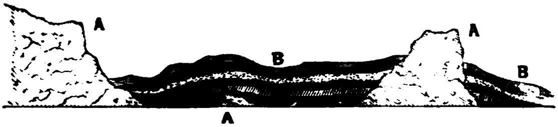


NOTE.

There are several theories with regard to the former condition of the earth. From the earliest ages of civilisation, the earthquake and the volcano have been a puzzle; and it is probable that the ken of man will never fully penetrate into the interior secrets of the globe, or that he will be enabled to form a correct solution of its mysteries. He may picture to himself, in imagination, whatever is most easily reconcilable to his own ideas, the permanency of the laws of nature, enabling him to reason from analogy; but it is questionable will he ever arrive at deductions which can be pronounced unerring. It would, therefore, be premature to assign infallibility to any theory. There are many who hold that solidification began at the centre, and this opinion has several followers at the present day, the subject matter of which is given at greater length in page 123 following.

impute the formation of all other rocks to the disintegration of the first crust of the earth.

In the Preface to this edition we have described the periods into which the older and newer formations of rock are divided:—The Azoic, the Palæozoic, Triassic, Cretaceous, and Tertiary. In accompanying plate, the Azoic is represented by the igneous rocks, the Palæozoic by the Cambrian, Silurian, Devonian, and coal measures, which are called primary; the Triassic, Jurassic, and Cretaceous are next in order, and denominated secondary. Eocene, Miocene, and Pliocene represent the tertiary, over which are the Alluvial and Diluvial, composed of gravel, sand, and clay, forming the surface of the earth; but in this order they never occur in practice. The following diagram shows how the igneous rocks disrupt the sedimentary.



A A A Eruptive Rocks; B B Sedimentary Rocks.

Referring to our plate, the igneous rocks occupy the lowest position, and, ascending, we find the Cambrian, Silurian, and Devonian, called primary. The term Cambrian derives its name from its strata, being the oldest rock visible in North Wales—the ancient Cambria; Silurian is derived from these rocks, occupying parts of England inhabited by the Silures, a tribe of ancient Britons; Devonian implies the old red sandstone rock, which is abundant in Devonshire; carboniferous, or coal-measures, are also included in the primary formation, and consists of limestone, shale, grit, and coal seams. In the secondary system is the Permian or newer sandstone, so named from the province of Perm, in Russia, where Sir R. Murchison investigated its nature, and from this its name arises. The Triassic is subdivisable into three groups, whence the name, and consists of the newer sandstone, red marls, and thin beds of limestone. Jurassic: the name is derived from the Jura mountains, where this rock abundantly occurs; it is known under the term Oolite, of which a great number of varieties exist.

We now come to the Tertiary Series, and of these the Eocene, as its name indicates, is the oldest and contains the smallest proportion of existing fossil species. It comprises, gypsum, *calcaire grossiere*, or coarse limestone and London clay. The Miocene includes a lower and a more recent deposit in which the newer sandstones are comprised. The Pliocene is known as white and red crags; a shelly freestone being a large admixture of fossil, shells, and gravel, united by calcareous matter. The Alluvial and Diluvial require no explanation.

That countless ages elapsed during the formation of the successive beds of stratified rock is apparent when we recognise the slow agencies by which similar effects are now produced. As we have before mentioned, the igneous rocks were at different periods upheaved: and as each convulsion necessarily produced corresponding changes in the disposition of the waters of the ocean, the dry land previously formed was overflowed; and this, with the grinding of ice sheets and wearing away by the action of rain, together with continuous thaw in the higher altitudes, caused the detritus to be carried away and held in suspension by water. The heavier particles subsided, and the lighter formed other deposits over them. These are the Cambrian and Silurian rocks, the first of stratified formation; and we invariably find them bearing traces of combination with igneous matter. These were again upheaved, or partially so, and worn away in their turn, until they became the foundation of limestones and marbles, whose component parts are simply a deposit of terrestrial substances, with an immense intermixture of fossil product of marine origin.

The formation of sandstone is easily shown. It is the detritus of former rocks carried into the sea; and anyone standing upon a beach, beholding wave after wave depositing layers of sand, sees it going on at the present. It is only necessary that this beach should be submerged and subjected to the pressure of water to produce sandstone.

It needs no great stretch of imagination to prove, at some period of geological history, that Ireland was divided into two distinct islands; and at another more remote that it consisted of a series of islands, formed by some of the present mountain ranges; and that these now form our most elevated districts is verified by the presence of ancient sea-beaches and deposits of marine shells approaching the summits of many; while it is palpable to the most casual observer, from the present appearance of the greater portion of the central plain of Ireland, particularly the counties Galway and Westmeath, that the waves of the Atlantic flowed for ages over them, the limestone formation cropping out upon the surfaces worn by wave marks, while the deposit of boulders with large and small stones of pebbly origin incontestably prove the former scene of an ocean bed, as we have shown in the beginning of this chapter.

Although time illimitable has since then elapsed, it may not be uninteresting here to show that numerous instances of the alternate elevation and depression of the earth's surface within historic times have occurred; but perhaps one of the most remarkable examples is that of the Temple of Jupiter Serapis, of which three columns are still standing at their original full height upon the shore of the bay, Baiae near Naples. There is sufficient evidence to show that the building—a quadrangular structure of forty-six columns in its original, the foundations of which can still be traced—stood some distance above high-water mark, and, from inscriptions yet remaining recording its embellishment, that it was erected at the commencement of the third century. In 1530, it is described as being covered by the sea; eight years later the coast line of Baiae was again raised twenty feet, with a tract of 600 feet in breadth, and the building re-elevated to its former position.—(*Vide* Lyell's "Principles of Geology," vol. i. chap. xxv. page 522.)

No doubt the most extraordinary instance of volcanic action in recent times is the elevation of the Jorulla Mountain, a few miles west of the city of Mexico, where a tract of from three to four miles square, occupied as a farm by M. Jorulla, was, on the 29th of September, 1759, with little previous notice, lifted up in a single night into a mountain 1,600 feet over the plain. Jorulla's farm was destroyed, but the mountain bears his name, which will possibly be perpetuated until the end of time.

That there has been a depression which formed Lough Neagh is certain, but we cannot adopt the tradition so beautifully alluded to by Moore in the lines—

> "On Lough Neagh's banks, as the fisherman strays,"

although it has been partially verified by modern scientific research; therefore it possibly may have some foundation in truth from the volcanic evidences of the entire of Ulster.

Lough Neagh is traditionally stated to have been formed by an irruption of the sea in the year 62; but it is obviously formed by the confluence of the Blackwater, Upper Bann, and other rivers. That its bed and that of the adjoining lake (Lough Beg) may, at a remote period of Irish history, have been partially dry land, is not at all inconsistent with belief, because their only outlet is the Lower Bann, which is obstructed by weirs, many of them large masses of boulder carried down at remote periods by floods and deposited in its course. The ordinary level of Lough Neagh is forty-eight feet above the sea at low water; Lough Beg is fifteen inches lower; therefore an irruption of the sea without a depression of their present beds, of which we have no record within historic times, is not likely to have occurred; however, according to Mr. Hardman, of the Geological Survey, it is to a depression of the surface from faults occurring in the underlying strata the origin of the lake is due; therefore we have some faith in the poetic fancy of Thomas Moore. Mr. Hardman, we feel assured, is perfectly correct in his views; but referring to the tradition—

"The round towers of other days,"

we have Scripture history to tell of the submergence of the cities of Sodom and Gomorrha, which stood upon the plains of Jordan, "well watered everywhere as the garden of the Lord like the land of Egypt." This plain of Jordan is now depressed 1,312 feet below the waters of the Mediterranean, and covered over by the Dead Sea. Gen., chap. xix., tells us the "Lord rained upon

Sodom and Gomorrha brimstone and fire from the Lord out of heaven." No doubt this was volcanic action discharged from the earth; for, as we find further in v. 28, "Ashes rise up from the earth as the smoke of a furnace." The surface now occupied by Lough Neagh may have had a milder form of depression, and perhaps both Thomas Moore and Mr. Hardman are correct in their ideas.

A great portion of the elevated heights of Leinster, Ulster, and parts of the coast-line of Galway and Donegal consist of granite; the entire central and portions of the southern districts lying at a lower level are of limestone, and form the great limestone plain of Ireland, occasionally interspersed with sandstone and numerous boulders; while the southern ranges, with part of the south-eastern, are of sandstone and clay slate. Carrantoul, the highest mountain in Ireland, is of the former formation; and so, also, are many of the mountainous districts of the west; while several of the headlands of Kerry, also Mangerton, Macgillicuddy, and the Glengarriff (Cork) mountains—presenting some of the boldest, most diversified, and picturesque scenery in this island—are of the latter.

CHAPTER II.

GRANITE.

Its Formation—Durability—The county Wicklow—Dublin Bay—Its Distribution—The Mourne Mountains—Absorption of Water.

GRANITE is a primordial rock, never stratified, and is one of the earliest portions of the crust of the earth, and yet we find it most generally occupying its highest levels, having forced itself through the superincumbent masses of later formations and overlying them, or else it has inserted itself in them as veins, in both instances completely altering its own and their texture when in actual contact; numerous erratic blocks are also found as boulders remarkable for their enormous dimensions. In the gigantic monuments of the ancient Egyptians we have irrefragable proof of its enduring power, and the immense monoliths it can be quarried in, which have no limit except their transportation and erection. Still in several localities it is easily disintegrated, and even decomposed. We have evidence of this in the cuttings at present proceeding for the Dublin and Wicklow Railway between Dalkey and Kingstown, where sections of it may be chopped away with a spade, and in such form it may have been deposited by water, the disintegration occurring at the surface of the earth.

NOTE.

GRANITE MONOLITHS.

A CURIOUS enquiry suggests itself when we consider how these blocks have been quarried. Modern history tells us that the Hindoo natives of India, in 1805, raised from its quarry bed the great obelisk of Seringapatam. The surface of the stone was prepared on three sides, and then a groove of about two inches wide, and somewhat deeper, was chiselled out along the whole length of lines on the fourth, where it was intended to separate the stone. A fire was lighted from end to end, and when sufficiently heated, cold water was poured into the groove, and thus caused a clear fracture without further labour; but, with regard to the Egyptian mode, Mr. Basil Henry Cooper, in a paper read before the Society of Arts, London, has, perhaps, sufficiently explained it. He states that, at Assouan, an unfinished obelisk lies in its original bed in a preparatory state, and that the stone is between 30 and 40 yards long. We will give his own description:

"The form of the obelisk, it seems, was first roughly outlined, by cutting longitudinal gashes in the granite rock; three of the sides were then pared into shape and polished, while the fourth was left still clinging to its native bed. To detach the shaft in its entirety, deep grooves were cut lengthwise underneath, into which were driven wooden wedges; these wedges, being moistened, swelled, thus loosening the stone, and drying, they were squeezed further in and again wetted, and this process being often repeated, split the granite at last without any shock in the direction wanted." It is a question whether the Hindoo method was not preferable to this; at all events, theirs must have been much more rapid in its operation.

Ireland is considerably indebted for some of its most picturesque and beautiful scenery to its granite formations. In the county Wicklow, the Devil's Glen, Powerscourt, Djouce, Lough Bray, Lough Dan, Luggelaw, Glenas-ane, Glendalough, and Glenmalure, have a world-wide fame, and all have special attractions, to picture which would occupy too much space in these pages. The Dark Valley and Lake of Glendalough must be sufficient with its towering masses piled one upon the other, so that it seems almost, to use the words of a celebrated author, "as if there was nothing more awfully grand in nature;" and of which our national poet has written—

> "Whose gloomy shore
> Skylark never warbles o'er."

In truth, it is a scene never to be forgotten, encompassed as it is, except on the east, by giant masses of rock, in some places rising in perpendicular cliffs from base almost to summit, where human foot has never trod, and where the eagle builds his eyrie far away from the haunts of man.

According to Lyell's description of this formation, it is "an unstratified or igneous rock, inferior to or associated with the oldest of the stratified rocks, and sometimes penetrating them in the form of dykes or veins. It is composed of three simple materials—felspar, quartz, and mica; and derives its name from having a coarse, granular structure—*granum*, Latin for grain."

Felspar is the chief ingredient in many of the igneous rocks, and originally a German miner's term, "feld, field, and spath," applied to a kind of gypsum called selenite. Mica, from the Latin *micare*, to shine, is a simple mineral having a shining, silvery surface, and capable of being split into exceedingly fine laminæ, and is used in Siberia, where it is abundant for glazing purposes; it is often confounded with talc, a different substance. Quartz is described farther on.

The districts where granite occurs are always elevated (showing its igneous origin), and in parts of Ireland they form extensive mountain ranges—as Donegal, Wicklow, Dublin, and Mourne—sometimes approaching the wildly picturesque, and forming marked features in the accompanying scenery.

Dublin bay is largely indebted for its attractions to the Killiney and Dalkey hills, as well as the background of the Three Rock range; while from an inland view their bold outline presents a pleasing contrast with the gentle undulations of the limestone formation.

Granite exists in considerable quantity in the counties of Dublin, Wicklow, Carlow, Down, Galway, and Donegal, and in the central districts, in isolated masses, either in small patches or in the form of boulders. The granite district of Dublin commences on the sea-shore at Williamstown, extending through Blackrock, Kingstown, Dalkey, and Killiney, to Bray Head, stretching inland to Golden Ball, Sandyford, and Dundrum, until it reaches the borders of Kildare. The Wicklow granite, which is a continuation of the Dublin formation, commences inside Bray Head, and passes at a distance of some miles from the sea-shore inland, until it approaches New Ross, in the county Wexford, extending in a parallel line bordering upon Kilkenny and into Carlow.

The Newry granite, as it is called, occupies portions of the counties Down and Armagh, and constitutes by far the greater part of the hills of Carlingford and the mountains of Mourne,* which form so attractive a feature in the scenery of Carlingford Bay. The Galway granite commences at Galway, and stretches along the coast to Roundstone, its northern edge passing close to Oughterard and including the islands off the coast. The Donegal granite, largely intermixed with quartz, stretches inland along the north-western shore for an average distance of eighteen miles, while its entire length is about thirty-five miles.

Granite varies greatly in quality and fitness for building purposes. In the county of Dublin, from the quarries of Dalkey, it is of an exceedingly hard nature, of a bluish tint, and difficult to work, but is a most endurable stone, and takes a high polish. At Golden Ball it is of fine grain, undistinguishable from the best quarries in Wicklow; while towards Dundrum, it is coarse-grained, friable, and altogether unfit for any but the roughest work. The surface stone everywhere in the county near Dundrum, and further south, is largely intermixed with mica; the mountain streams, carrying it down in its disintegrated state, accumulate quantities of this glittering substance in their sand-banks. At upper Lough Bray the shores are literally composed of laminated beds of mica averaging the size of sixpence; we have often collected quantities of it. Wicklow granite, from its even and close texture, can be chiselled into every variety of moulding, and may easily be carved into Corinthian and Ionic capitals, particularly when they are of large diameter; but it is not to be recommended for the latter purposes, as the greater the facilities it affords the less enduring is the stone.

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* This group is remarkable for the number and variety of the rocks and minerals of which it is composed.

Carlow granite is celebrated for the facility with which it splits into long lengths, and small scantlings; also for its whiteness, easy working, and durability. All over the county, but particularly in the vicinity of Bagnalstown, fences of the simplest kind made of this stone are to be seen formed by the upright pieces sunk in the ground, with continuous lintels, averaging from 6 feet to 9 feet in length, laid over them, which require no fastening, as the weight of the longitudinal stone keeps it steady upon the upright; a quickset hedge is generally planted underneath, and it forms the most impervious of all fences. It is a beautifully close-grained stone, and can be worked into almost all ornamental purposes for building.

The granite of the Mourne mountains is of a flesh-red colour, easily wrought; some specimens are bluish gray, and polish admirably.

A great variety exists in Galway granite; some of it is coarse-grained, with a large intermixture of quartz, but it is generally suitable for ordinary purposes.

The quarries of Donegal have not as yet been sufficiently worked to pronounce a fair opinion upon the stone. It is coarse and very granular, with a reddish tinge, and generally soft and easily disintegrated. Where deeper workings have been effected it is of strong but coarse quality, with quartz as its prevailing feature.

The tendency of stone to absorb moisture greatly determines its power of resisting the action of the atmosphere. As granite and limestone are the two principal building stones of Ireland, it may not be uninteresting to know how this property exists relatively between them, and which we are enabled to give from Mr. Wilkinson's experiments. The average weight of granite is 170 lbs. per cubic foot, varying from 143 lbs. to 176 lbs.; and if immersed in water, the Newry and Dalkey granites absorb ¼ lb., Carlow 2 lbs., and Donegal 4 lbs.

The average weight of limestone is 170 lbs. per cubic foot, varying from 159 lbs. to 180 lbs.; if immersed in water it absorbs but ¼ lb., its greatest absorption is ½ lb., this tends to prove there are no varieties of granite superior in durability to limestone.

CHAPTER III.

THE CAMBRIAN ROCKS.

Mica and Clay Slate—Remarkable Example of Mica Slate at Killiney; its distribution—Extent of Clay Slate Deposits—Roofing Slate; where Quarried; peculiarity of Cleavage—Quartz or Rock Crystal—Gneiss.

WE have given the theory of the formation of granite, the foundation and basis upon which all the other rocks have been erected; and we have shown how, by sedimentary deposit, layer after layer has succeeded each other, built up like courses of masonry by the Great Architect of the Universe; and, as compared with all measures of time familiar to us, the formation of these successive strata must be counted back by periods illimitable, to which our knowledge of this earth's surface necessarily appears recent when contrasted with the historical data indelibly written upon it.

The rocks of the Cambrian system are the oldest of geological history, and are of argillaceous origin, therefore of sedimentary deposit; but before entering into consideration of any, it may be necessary to remark that each of these strata partake in a greater or less extent of the nature and character of the rocks they are superimposed on; and it is often difficult, sometimes impossible, to trace the beginning of the one and the ending of the other, and *vice versâ*. This has given rise to numerous subdivisions of the different groups; but to follow them would be unnecessary for the purpose of these chapters, besides extending them to far greater lengths than would be desirable. We will, therefore, confine ourselves to the description of the principal strata of each. Some examples of this system are composed of green and purple grits, quartzites, and rough slates, fine sections of which are shown in the steep cuttings of the Dublin and Wicklow Railway round Bray Head. The Sugar-loaf Mountains are also composed of it, and it stretches thence nearly as far as the town of Wicklow; further on it is found along the coast of Wexford, and near Dublin in the promontory of Howth.

Mica slate, usually found resting upon granite, graduates imperceptibly into the clay slate which is generally found resting upon it. Although this rock is largely developed in Ireland, it does not occur to any great extent in Leinster. Commencing at Killiney, a remarkable example of mica slate—or mica schist, as it is called—exists in the cutting which forms the land side embankment of the Dublin and Bray branch of the Wicklow Railway. Midway between Killiney station and the mouth of the Dalkey tunnel a large extent of stratum largely impregnated with iron is observable, and it is thrown into every variety of position, from nearly horizontal to perpendicular, whence it extends in a narrow fringe edging the granitic districts by Bray Head through Wicklow and on to Wexford. In Mayo, Donegal, Derry, Tyrone, and Galway it is a most important rock, as covering large surfaces; but it is altogether absent in Munster. Clay slate is divided into two formations—the upper and the lower, and generally overlies mica slate: but this does not always follow, as it is sometimes found directly resting upon granite. The lower division extends over an immense area in the counties of Cork, Kerry, Waterford, Wexford, Louth, and Down. The upper occupies the greater part of the south-west of Kerry, stretching into the adjoining county of Cork, and extends thence to Dingle Bay. The bold peninsular character of these districts, forming the magnificent bays of Bantry and Kenmare, with the picturesque heights of several of the Killarney mountains and the wildly beautiful scenery circling Glengarriff, are altogether due to the natural formation of this rock. It is found in other parts of Ireland, but in limited quantity, as in Armagh, Tyrone, Derry, Donegal, Down, Clare, Wicklow, Waterford, Wexford, and Mayo.

Roofing slate has been quarried in Ireland with more or less success for a considerable period; and, according as greater depths have been arrived at, the quality is much improved, some of it scarcely inferior to the best Bangor. It is found at Broadford, Ballagh, and Killaloe, in Clare; Cahir, Begnish, and Valentia, Kerry; Rathdrum, Carnew, and Dunganstown, Wicklow; Clonakilty, and Kinsale, Cork; Ross, Lismore, and Glenpatrick, Waterford; Westport, Mayo; Newtownbarry and Kilkeven, Wexford; Letterkenny and Buncrana, Donegal; Bangor, Ballywalter, and Hillsborough, Down; and at Crossmeglen and Newtownhamilton, Armagh; but the principal quarries are at Killaloe and Valentia. Sir Robert Kane states, in his "Industrial Resources of Ireland," that slabs of Valentia slate are easily obtainable 30 feet long, from 4 feet to 5 feet wide, and from 6 inches to 12 inches in thickness; and he appears to think it might safely be used in place of bearing timbers for the support of floors and ceilings of large rooms. There are specimens in the Museum of the Royal Dublin Society from Killaloe quarries of as large an area as 10 feet superficial measurement, and this slate is largely used for roofing purposes. Valentia slate does not split so delicately as Killaloe; it is, therefore, not as suitable for the finer qualities of roof slate, and is consequently more employed in the form of slabs and for flagging, for which the large dimensions it is obtainable in render it suitable.

A curious peculiarity exists with regard to slate rocks. Their line of cleavage is invariably at an angle different from their horizontal beds. All other sedimentary rocks split in the line which is known to have been that of their deposition; but with slate this line of cleavage is at an angle differing from what was its original bed: hence, it has been concluded that some great predisposing cause, as a large amount of subterranean heat must have pervaded the entire system subsequent to the deposition and disturbance of their strata, which has had the effect of rearranging their constituent parts in this peculiar manner; and this is the more easily accounted for from their immediate contiguity to the granitiform rocks.

Clay slate is an important material in the numerous localities in which it occurs, because, where it will not split in laminæ sufficiently thin for flags or roofing purposes, it affords a valuable stone for ordinary building works.

Quartz, one of the constituent parts of granite, and entering into combination with many of the varieties of sandstone, is most generally found associated with the mica and clay slate formations, occurring in large veins protruding through, and in great beds cropping out on the mountain ranges of slate districts. It contributes largely to the wildly romantic attractions of Connemara, forming the summits of some of its highest mountains, particularly Benabola, or the Twelve Pins, and also to the picturesque beauty of the Bay of Dublin in the panoramic view of the peninsula of Howth, with Bray Head and the Sugar-loaf Mountains, which are all capped with it.

In Wicklow it constitutes the extensive mountain range stretching from the Avonmore to the Vartry, and also Coolatin Hill, Shillelagh. In Wexford it is general throughout the county, occasionally met with of a deep red tinge, from its impregnation by oxide of iron. It is of pure white near Killogue, and known as the white rock. It also forms the substratum underlying a large portion of the town of Wexford.

The surface stone of the north Island of Arran, in Galway Bay, is entirely of this formation. Flesh-coloured quartz in large veins permeate the granite districts of Armagh. It occurs in massive rounded boulders near the southern coast of Kerry and near Kerry Head, as well as in many other parts of Ireland.

Numerous beautiful specimens of quartz crystal are found throughout the Island, occasionally of various hues, according to the colouring matter they have imbibed. Colourless hyaline quartz, or rock crystal, is abundant, and often called Irish diamond.

Quartz is, properly speaking, silex, the latter being its chemical name, used to designate the oxide of silicium always found mixed with it; several different varieties of this stone occur from the various mineral substances it contains, thus:—

Purple quartz, or amethyst, is coloured by alumina and oxide of iron, and is of every variety of tint of purple violet; cairngorm presents a smoky appearance, and contains a small quantity of bitumen; chrysoprase obtains its light green colour from nickel; opaque yellow contains a considerable proportion of oxide of iron, and is called ferruginous quartz; the green, yellow, Bohemian, and red quartz all derive their shades from metallic oxides.

Gneiss is a stratified rock, but consisting of the same material as granite, and usually containing a larger proportion of mica in its composition; the name is of German derivation, and it is supposed gneiss is granite in its disintegrated state, carried down by water, and deposited in successive beds like all other sedimentary rocks; but the crystalline texture it has assumed can only be explained by its being subjected to pressure, and acted upon by subterranean heat; it is, therefore, what is called a metamorphic rock.

CHAPTER IV.

Sandstone, Description of—Fossil Remains—Its Distribution in Ulster, Connaught, Leinster, and Munster.

THE sandstones are most widely distributed, occupying, in one form or another, almost every county in Ireland, and are, therefore, most important. They are divided into two distinct groups—the old red and the new yellow; old and new comparatively, when considered in relation to the vastly different periods of their formation. But the term red is not literally correct, because this tinge prevails but in few instances, and arises, where it occurs, from a greater quantity of oxide of iron permeating through it than is general with Irish sandstone. The late Sir R. Griffiths considers that the carboniferous strata of the county Cork should be considered a third formation. As this is an isolated strata, and does not occur in any other of the Irish counties, it may be better to recognise only the divisions above given. Conglomerate is sandstone in its coarsest form, and consists of pebbles of different sizes cemented together with calcareous matter. Where the clay slate joins sandstone the texture of both becomes modified, and the colours and peculiarities of each are blended together, forming the material which is quarried as flags in different parts of the country.

There is no more interesting study in geological history than the sandstone formation—occasionally preserving the impressions of the most delicate plants, minute insects, shells, fossil fish, the footprints of aquatic birds, the rippled surface left on the sea-shore after the tide has receded, and the patter of the rain-drop, both vertical and oblique, showing the point of the wind whence its course had been directed—all these perfectly preserved in their sharpest outline; and in them we have records written in indelible type of bygone periods and ages far removed from our time, yet so plain as to be identical with what is within our reach day after day. Limestone offers remarkable examples of fossil remains in its numerous preserved shells, &c.; so also does the coal formation, but in a different way in the flora of past ages, reproduced to us in the most marvellously minute manner; but in no other but the sandstone formation can we so manifestly recognise the power of the Great Creator, completely and perfectly familiarised to our understanding.

As we have before mentioned, the distribution of this stone is very general; and, taking the provinces and counties as they occur from the map, we will commence with Ulster.

In the mountains of Donegal it exists in considerable quantity, resting upon limestone, and overlaid by granite, but being near their summits it is an inconvenient position for use.

In Down, on the sides of Strangford Lough, for a length of about seven miles, it rises in some parts 350 feet, capped with green stone rising 150 feet more; from these quarries the celebrated Scrabo stone is obtained.

There are also quarries at Kilwarlin, near Moira, where flags of considerable dimensions are raised, varying in colour from a light gray to a brownish red; but the quartzose sandstone of Fermanagh is a superior stone, being equal in durability and fineness of grain to any in the British Islands. Green sandstone, coloured by some metallic oxide, is general in Derry, and sandstone both of the old and new formation extends the entire length of the county, and surrounds its mountainous districts, stretching thence into Tyrone.

In the latter county the red sandstone occupies considerable portions of its southern and eastern districts.

In Monaghan it is found all over the country; and there is a peculiar and very beautiful white stone on part of Slieve Beagh, which is extensively quarried as being suitable for all architectural purposes.

In Antrim, as in Derry, a green sandstone is plentiful in the neighbourhood of Belfast. It also occurs near Carrickfergus and Larne, the underneath strata being red sandstone of a variety of degrees of fineness, in some places approaching to conglomerate, and in others of remarkably close texture; and this formation is found to prevail in the entire south-eastern borders of the county, and in detached masses along the eastern coast.

In Armagh there is a beautiful close-grained quarry at Grange, where sandstone of every variety of texture can be obtained.

In Cavan, the Slieve Russel mountain range, forming the boundary between Ulster and Connaught, is occupied principally near their summits by the new red sandstone formation, and in many parts it forms perpendicular cliffs of great height, producing scenery of the grandest and most imposing character. The summit of one of these mountains is entirely composed of it, forming a large table-land, split up and traversed in every direction by enormous fissures.

This stone is not as extensively developed in the province of Connaught as in Ulster. In Sligo there are numerous beds of a yellowish tint, and it is discovered in quantity in the mountain ranges. In Leitrim extensive quarries, and of a very fine grain of yellowish white colour, are worked near the summit of Glenfarm Mountain; there are also several quarries in this county.

In Roscommon it is to be seen in isolated hills, and forms the long range of Slieve Bawn, the summit of which is capped by irregular masses of it, looking like huge boulders. It is also quarried in several parts of this county as flags, which, from the evenness of their beds, are highly valuable. Mayo contains many valuable quarries of red sandstone, which is easily wrought and most durable stone.

In Leinster there exists even less of this material than in Connaught. In Westmeath, near Moate and Ballymahon, it appears in isolated protuberant masses. In Kildare, in a few of the hills, as Lyons and Grange Hill. In the King's County the Slieve Bloom Mountains are surrounded by it, and in these quarries excellent flags are raised from 7 feet to 8 feet square. At old Leighlin-bridge, in Carlow, there are the well-known quarries of argillaceous sandstone flags occupying a bed of 200 feet in thickness.

Isolated masses of sandstone are found in Longford; and a considerable space at both sides of the Shannon is occupied by it, extending into the adjoining counties of Roscommon and Leitrim. It occurs in Wexford in greater abundance than in any other county in Leinster, a great portion of its coast-line, forming bold and abrupt precipices, is formed by it. In the upper haven of Wexford it is easily distinguished by its deep red colour.

In Munster, many of the mountain heights are sandstone in mass, overlaid by conglomerate, as the Galtees. The lower range of Slieve-na-muck produces excellent flags of large dimensions, and extensively used for local purposes. In all the mountain districts of this county sandstone in great variety is obtainable; it is also very abundant in Limerick, forming the hills of Knockaderry, Ballingarry, and Killmeady, and the mountains forming the boundary line between this county and the adjoining one of Cork.

Kerry is largely supplied with sandstone; many of its mountains are entirely of this formation, and eastward on the coast the sea-cliffs are exclusively composed of it. So also are the range of mountains which separate Kenmare from Bantry Bay.

In Cork extensive quarries are worked near Bandon, and also at Innishannon; and it is found generally distributed through the county, but particularly along the coast-line. The south-eastern angle of Waterford is entirely composed of it.

The Sandstone Rock, called the Lion's Head, coast of Antrim.

CHAPTER V.

Limestone; its Composition, Distribution, Durability, Upper and Lower Formation, Intermediary—Uses of Limestone—Calp—Chalybeate Springs near Dublin—What is Lime?—Mortar—Caverns in Limestone—Stalactite and Stalagmite—Travertin of Italy—Sulphate of Lime in Boiled Water—Marbles—Oolite, Chalk; variation of into Marble Flint.

LIMESTONE, or carbonate of lime, is by far the most largely-developed rock in Ireland, and is an accumulation of fossil remains upon a scale of magnitude so vast, and dates back so far into primeval ages, as almost to exceed our powers of belief. There are few limestones in which these remains cannot be discerned in condition more or less perfect. Generally speaking, as marble, it has lost its stratification, and in some it has become crystallised—as in the purer examples—from being subjected to the action of subterranean heat, which has totally obliterated the traces of such remains. The limestone formation extends through the entire central districts, stretching from Fair Head to Dingle, north and south, and from Dublin Bay to Galway Bay, east and west, and occupying a superficial area of over 10,000 square miles; and there is no county except Wicklow where it is absent. Granite has often been described as the most enduring of stone, and this to a certain extent is correct, although applying only to limited examples, as we have already shown; but limestone, as a general rule, is a far more lasting rock. We have only to refer to the numerous remains of structures throughout the country in proof thereof, many of them still preserving their ornamentation in sharpest outline.

The limestone strata consists of three distinct beds, formed at widely different periods in the history of the earth; and these consist of the upper, the lower, and the intermediary, called calp. The lower formation is the most generally diffused, having been upheaved long ages ago through the other intervening stratified rock; it varies in colour and in texture from the light gray crystalline (as at Sheephouse, Drogheda), the light blue (of Galway, King's County, and Carlow), to the deeper shades of calp, and the Galway, Kilkenny, and Carlow marbles, together with the beautiful variations of green, red, and yellow, until it eventuates in the purest white.

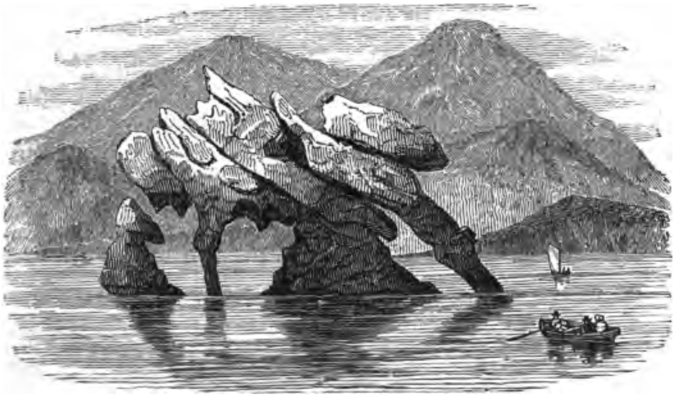
Carbonate of lime, either as limestone or in its different varieties of marbles, is the most important, the most useful, one of the most interesting productions of Ireland, whether as considered in its appliances to agricultural purposes, its uses in arts, manufactures, and medicine, or as limestone in its various applications to building, either as the main constituent of the structure, the materials of the art-ornamentation which adorns it, or in its calcined state, the cement which consolidates it together, and which latter, if judiciously treated, restores it again as material to its original state.

Calp, or the intermediary formation, is limestone, in its most impure state, nevertheless is highly valuable for building purposes; it is extensively developed throughout the country, but more particularly in Dublin, Cavan, Fermanagh, Leitrim Roscommon, and Sligo. Wherever it occurs it is largely used for rubblè work, and frequently employed as ashlar. It has one great defect—if not laid in its bed of deposition it speedily decays, falling away in laminated scales; and this will continue even when covered by a cemented or compoed surface, if exposed to atmospheric influences.

Calp is of much deeper colour, much closer texture, and considerably harder than ordinary limestone, but frequently of soft slaty formation, and occasionally shot with veins of crystallised carbonate of lime, which form the white streaks observed in this stone. Iron also exists to a small extent, and is sometimes seen in the form of pyrites, the glittering substances occurring in a few instances in some of its beds, as bisulphuret of iron, and it is from this source the chalybeate springs arise which occur in it. Several of these springs exist in the neighbourhood of Dublin, particularly in the valley of the Liffey; and there was one many years ago at Portobello, which has latterly given rise to much discussion. But the disputants seem to be unaware that sulphuret of iron in a quarry is not inexhaustible; the spring may remain, but the vein it has permeated through may long since have been washed out.

The origin of limestone is very remarkable, and as we have already shown in Chapter I., is a deposition of terrestrial matter carried down by rivers to the depths of the ocean, covering over the remains of shell-fish and coral animals, to which generation after generation had contributed their respective shares, where they arrived at great thickness and solidity, until at length they became hardened into rock by the infiltration of water holding carbonate of lime in solution, colouring matter being imparted to it by vegetable *débris* contained in the terrestrial matter above mentioned. But all these shells, &c., being composed of lime, and as they must have existed ages before what we now recognise as carbonate of lime was produced, the question naturally arises—What is lime? Lime, then, is an earth, the oxide of the metal calcium, and exists abundantly in sea-water; so also does carbonic acid, and it is generally allowed it is to the presence of both the formation of sea-shells is due, and to this source carbonate of lime owes its origin.

It is altogether unnecessary here to describe the process by which carbonate of lime is converted into hydrate or slaked lime; but it may be of importance to remark that mortar used for building, if properly treated, and made with pure sand, will, from the slow absorption of carbonic acid from the atmosphere, be again restored to its original form of carbonate. We have numerous instances of this in the ancient buildings throughout Europe. We have stated that limestone is most durable; but a casual observer passing through districts occupied by it will form opposite conclusions in observing its water-worn aspect throughout the country. In the lower lake of Killarney this is particularly observable, where the stone has assumed every variety of fantastic shape, occasionally looking like gaunt spectral forms rearing themselves above the surface of its waters.



Water-worn aspect of Limestone, Lower Lake of Killarney.

But it is in subterranean rivers and caverns where its disintegration is shown upon a scale of vastness, which many will scarcely believe is occasioned solely by the solvent power of water.

Carbonic acid will dissolve the hardest rocks, and every stream flowing through a limestone formation holds it in solution in considerable quantity; and, it is curious to remark, that the same power which produces limestone acts inversely, but only again to reproduce it upon an infinitely more extended scale in the depths of the ocean. The limestone formations of Ireland, entirely occupying its lower levels, form the beds of numerous rivers, and every fissure in the rock which allows water to permeate becomes a source whence underground water-courses are maintained, if lower levels are accessible; and in this way caverns are excavated in the solid rock, and rivers alter their courses underground.

We have many remarkable examples of subterraneous rivers, particularly in the county Galway. The drainage of Lough Mask into Lough Corrib is of this character. In the streams surrounding the village of Cong, which the late Sir W. Wilde, in his "Lough Corrib," page 161, thus alludes to: "There is water everywhere; gliding by in the broad river, gushing from the surrounding rocks, boiling up in vast pools that supply several mills, oozing through the crevices of stones, rising in the interior of caverns, appearing and disappearing where its wayward nature wills; passing in and out everywhere except where man tried to turn it into the monster dry canal." Nature will not be cheated; thus limestone districts always exhibit this peculiarity. Man cannot change what the Almighty dispenser of the universe has otherwise ordained.

Outside Oughterard, in the same county, a mountain stream has percolated underground, and excavated its course into Lough Corrib, passing underneath the ruins of Aughnanure Castle,* and also under a natural bridge which it has formed on its way. The fountain called the Marble Arch, at Florence-court Park, near Enniskillen, is of this character, and is well worth attention as percolating from its source through the Coulcagh hills, it forms a *jet d'eau* here. There are numerous such instances throughout Ireland; but perhaps the most remarkable is that of the river Ardsallus, in Clare, which winds its devious way through the celebrated Tomines—immense caverns, excavated by nature's hand, like vaulted tunnels, through the solid stone, their gigantic roofs superimposed over the river, while pendant stalactites of immense proportion, looking like huge Arctic icicles, meet you at every turn, the dim rays of light penetrating from the distance imbuing them with every variety of colour; although, from the metallic oxides they hold in combination, they need no reflected light; presenting, as Sir R. Kane observes, in his "Industrial Resources," "a scene of magnificence never to be forgotten by those who have viewed it."

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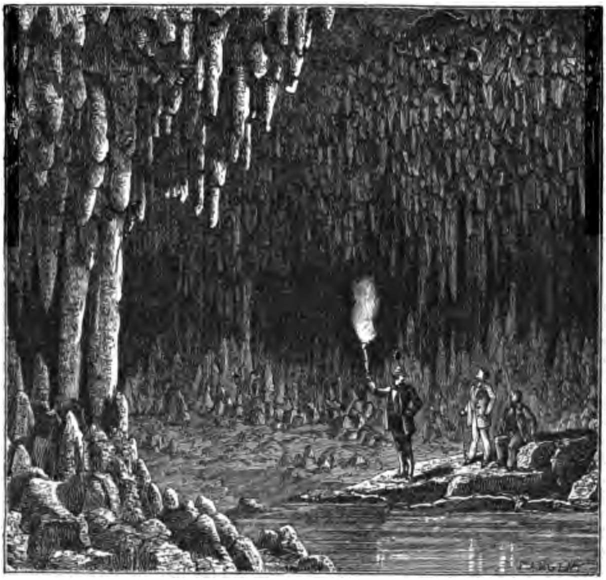
* This Castle is situated about two-and-a-half miles south-east of Oughterard; and there is a curious story in connection with the river, which has formed a course for itself under its walls, which we have already given some years ago in a description of the building, but it may as well be repeated here. "Tradition tells strange tales in reference to this Castle. Our attention being directed to a trap in the floor of the dungeon-keep, we were informed that prisoners were consigned after execution through it to their last resting-place, by being lowered into the torrent underneath, where their bodies were rapidly borne off in the stream."

The caverns of Mitchelstown, on the borders of Tipperary and Cork, formed in the limestone rock, and covering an average surface in their various chambers of 700 feet by 600 feet, exhibit the extraordinary power of this percolation of water; and again in its restorative qualities in forming stalactite and stalagmite, the magnificent columnar formations throughout these caverns almost defying description; the prismatic colours which they display by torchlight must be seen to be appreciated.

The caverns of Belmore Mountain, near Enniskillen, are another and extraordinary example. It is easy to understand how these immense chambers have been excavated, as we have already shown, by the power of water, and in the diversion of its course by percolation, or otherwise, at a different level, it has then almost abandoned them and left its own creation to the restorative influences of stalactite and stalagmite; but it is difficult to imagine how the deep clefts in mountainous portions of the country have occurred. Split up chasms or passes almost perpendicular, through hundreds of feet of superincumbent cliffs, arrest attention, in numerous instances. In the county Cork, the pass of Keim-an-eigh is one of the most remarkable. Giant masses of beetling rock rise to stupendous height at either side, the arbutus, the

CAVERNS OF MITCHELSTOWN.*



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* "The Garret Cave extends 255 feet in an easterly direction, with a sweep to the south. Its breadth at the commencement being fifteen feet, and augmenting gradually, until at its widest part it becomes 55 feet.

"The grand Kingston Gallery is the most remarkable compartment of the entire excavation. It is a perfectly straight hall, 175 feet in length and seven in breadth, with a direction about one point to the west of north. The arching of this gallery is in the Gothic style, and its walls are everywhere glazed with spar, in some places red and in others mottled, but nowhere of a perfectly white colour."—Dr. Apjohn in Dublin *Geological Journal.*

Stalactite and Stalagmite. Ardsulus, Clare.

Stalactite and stalagmite are produced by water holding carbonate of lime in solution, percolating drop by drop through the overlying strata from the roofs of caverns in limestone districts, the stalactite hanging down like icicles; while the dropping underneath from which, when consolidated, is called stalagmite, the water evaporating, leaving behind successive crusts of carbonate of lime. Stalactite and stalagmite eventually unite, producing column after column, sometimes clustered and sometimes isolated, which, when hardened by age and absorption of carbonic acid from the atmosphere, produce variously-coloured stone, according to the mineral character of the veins the water which produced them has permeated through.

In volcanic countries petrifaction is produced in much shorter time than with us, the celebrated travertin of Italy (according to Lyell) becoming "a solid stratum of stone about a foot in thickness in four months;" it is hard and crystalline, and yet it is only a deposit from the water of springs holding lime in solution. Where these springs exist a very beautiful and highly-interesting method is devised for producing works of art in stone. The streams containing the lime are diverted and made to pass over falls, so as to produce exceedingly fine spray. Moulds of suitable material are then hung within its reach, and after the lapse of a few days they are completely encrusted in stone, with every line as perfectly drawn as in the original.

Before the introduction of the Vartry system into Dublin, the incrustation of lime in vessels used for boiling water was well known, forming a solid mass, which, after a short period, became almost impossible to remove. The canals which supplied this water, running through limestone districts, held a large quantity of carbonate of lime in solution; also sulphate of lime, from the springs rising through the calp formation in which portions of their courses lay; being afterwards exposed in the city basins, they imbibed sulphuric acid from the smoky atmosphere; and it is possible that these incrustations, if collected, could have been converted into what is known as Paris plaster.

With regard to marbles, an immense variety exists, and it is unquestioned there is no lack of quantity, which the following extract from Dr. (now Sir Robert) Kane's "Industrial Resources" fully demonstrates; but, unfortunately for the country foreign marbles are to be had in abundance, while the native material cannot generally be obtained manufactured. In this we must except the celebrated Galway (black), and in a lesser degree the Connemara (green), for both of which there is considerable demand; and we are happy to observe that within the last few years a considerable impetus has been given to the manufacture of Irish marble.

"The limestone districts of Ireland contain numerous beds, which the closeness of texture and the purity or variety of colour render available for ornamental purposes as marbles. I shall only enumerate the localities in which the most remarkable marbles are found. There is no county which does not afford specimens of greater or less excellence. The principal quarries of black marble are those of Kilkenny, and near the town of Galway; these are both in the upper limestone. The Kilkenny marble takes a beautiful polish, and when first cut is quite black; but the organic matter to which its colour appears to be due gradually passes off, and ultimately white marks of fossils of varied and interesting forms present themselves upon its surface. The Galway marble quarries are situated along the verge of Lough Corrib; they supply a large quantity of marble annually to London and New York, but are capable of almost indefinite development. Near Armagh is found a marble which, from the excellence of its surface, and the variety of red, yellow, and brown tints which it shows, possesses great beauty; it contains abundant remains of fossil fish.

"A similar marble, elegantly variegated with yellow and purple, occurs at Churchtown, in Cork, which county is indeed rich in this material, there being found black marble at Churchtown and Doneraile; purple and white and blue and white marbles also at Churchtown; ash-coloured, gray, and dove-coloured marbles at Carrigaline and Castlemary; pale brown marbles at Kilcrea.

"In Kerry there are black and white variegated marbles near Tralee; and in the islands in the river Kenmare, near Dunkerron, marbles of various colours—black and white, purple, white, and yellow, and some specimens of a purple colour veined with dark green, resembling blood-stone.

"At Craigleith, in Down; at Lyons and Ballysimson, in Limerick; at Westport, in Mayo; and at Castlebegs, in Tipperary, are quarries of black marble. At Clondeslough, in Clare, a fine bourdella marble. Near Shannon-Harbour, on the Galway side, fine sienna and dove marbles. At Clonmacnoise, King's County, and Dromineer, in Tipperary, are fine gray marbles variously tinted, and peculiarly sound and useful. At Killarney occurs a very beautifully-striped white and red marble; and a brownish red, mottled with gray of various shades, at Ballymahon, in Longford.

"The primitive limestones of Connemara and Donegal supply white marbles, which in Galway is often absolutely pure in tint, but in Donegal it is more frequently of a grayish cast. The Galway marble has been already noticed as the strongest of limestones when used for building.

"The West of Galway and Mayo is also remarkable for the serpentine rocks, which afford the beautiful variegated green and white marbles so deservedly esteemed; the most valuable quarries of this remarkable mineral are situated near Clifden, on the estate of Mr. D'Arcy. This marble is exported in considerable quantities."

Large quantities of continental marbles are annually imported into Ireland, many of them very inferior to what can be produced at home. We have often stood in amaze looking at the numerous quarries of Galway, particularly in the neighbourhood of Oughterard, where, if easy access to the water carriage of Lough Corrib were available, mines of inexhaustible wealth would be made accessible.

Oolite. This stone is very extensively developed all over the world, and consists of the shells of the most minute description of foraminiferæ, which existed in millions upon millions of myriads in the waters of primeval seas. Pouchet in "L'univers Les infiniment grand, Les infiniment petits," Paris, 1867, tells us that Paris, the most beautiful city in the world, is built of microscopic shells, being the labour of minute insect life in the far depths of the mighty waters.

Oolite is recognised as a carbonate of lime (of which the Bath and Portland stones of England are familiar examples), and found only in Antrim, Mayo, and Derry. Its name is derived from two Greek words, signifying the roe or ova of fish which it is not unlike, being composed of small grains resembling sand closely cemented together by calcareous matter. Being easily worked, it is most useful for decorative purposes, and hardens by exposure to the weather; but it does not occur to any extent in Ireland. Like all other formations, it is divided into different groups, among which the argillaceous laminated stone called lias is found, which, from its fine-grained texture, is much used by lithographers.

Chalk is another, and nearly similar example of the work of minute insect life. It consists of the following divisions:—Upper chalk, a soft substance which you can scrape with your nail, and contains nodules of chert and layers of flint; lower chalk, a much harder substance, examples of which are seen under the basalt on the coast of Antrim; and chalk marl, containing a mixture of marl.

The green sands are also classified in the chalk or cretaceous system.

Chalk exists in considerable quantity in the counties of Antrim and Derry; the basis of the entire north-east coast of the former county is composed of it, and it stretches to a considerable distance southwards. It is upon chalk rock, which presents a characteristic feature in the abrupt prominences of the sea-board line stretching from Strangford Lough and beyond the romantically-elevated Castle of Dunluce,* that the columnar basalt rests. In many of the mountain districts of Derry chalk crops out on the acclivities, capped by massive basalt. Along the Portrush coast it is well developed, and many interesting examples are seen in the white rocks of Dunluce. Where veins of trap have been forced through it, it is converted into limestone generally of a crystallised texture and considerable hardness, and this, to a large extent, on both sides of the invading vein.

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* Underneath the Castle of Dunluce is an immense cavern, excavated by the continuous action of the sea on the chalk formation upon which the superincumbent basalt rests; and there is a tradition attached, that part of the floor of one of the apartments over this cavern suddenly

Dr. Berger (Geo. Trans., 1st series, vol. iii. page 172) thus writes in allusion to these veins:—"The extreme effect presents a dark brown crystalline limestone, the crystal running in flakes as large as those of coarse primitive limestone. The next state is saccharine, then fine-grained and arenaceous, a compact variety, having a porcelaneous aspect and a bluish gray colour, succeeds; this towards the outer edge becomes yellowish white, and insensibly graduates into unaltered chalk."

Flints occur in numerous instances throughout the upper depositions of chalk, and when examined by high microscopic power they are invariably found to include traces of animal life—some of the zoophytes, perhaps a sponge, in which silica has been deposited and accumulated.

Upper chalk, though highly absorbent of water, possesses the property of not permitting fluids to permeate through it; and it is in consequence

gave way, upon the occasion of a festival given by the Lady Margaret M'Donnel, and that the occupants, with one exception only, were precipitated into the sea.

largely used for the purpose of lining ponds and reservoirs. If a little salt be added, to prevent worms boring through, it forms the most effectual possible puddling for canals, water-works, &c. (Of course these remarks are only applicable to districts where chalk can readily be obtained, as the cost of carriage would act as prohibitory to its use at considerable distances.)

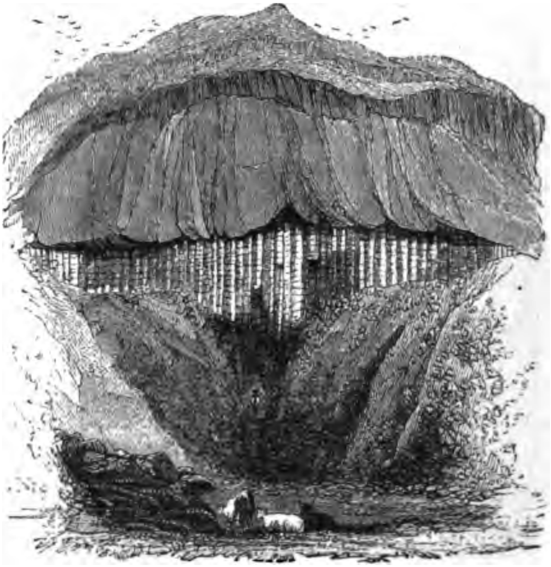
Gypsum, or sulphate of lime, is lime combined with sulphuric acid; it is now acknowledged as with regard to the white marls of Montmartre—the largest known accumulation—(the Paris basin) that gypsum is a fresh-water deposit, but largely intermixed with calcareous marine matter, occurring, as we occasionally find it, in the course of a river being cut off in its connection with the sea, either by an elevation of the coast-line, as at Baiae, Naples, or in a more familiar way by the constant action of the tide elevating a beach.

A few miles from Dublin there is a small mountain river, which delivers itself on the shore close to the Ballybrack station (Dublin, Wicklow, and Wexford Railway), having no apparent outlet, the tide continuously washing up sand in its course; and the river water (except in the case of floods, when it forces itself through the obstruction) has no escape except by percolating through the constantly-recurring barrier of sand raised against it. During the prevalence of high tides the estuary of this river becomes a salt water basin; and, if its course lay through a limestone district, gypsum would form in considerable quantity therein.

CHAPTER VI.

Trap Rock—Basalt: General Remarks upon—The Giant's Causeway—Columnar Form: Description of—Sculptures—Greenstone—Gypsum—Boulders—Shells and Marl—Sand and Gravel Ridges.

VOLCANIC rocks are designated by the name Trap or Trappena, and are found in the form of veins protruded through or overlying other rocks in tabular, columnar, or horizontal masses.



Columnar Basalt. The Giant's Organ, coast of Antrim.

The term trap is derived, according to Lyell, from the Swedish word "trappa," signifying stair, because rocks of this class frequently occur in terrace-like masses, rising tier over tier above each other, as gigantic steps of a staircase. A remarkable example of this kind of formation exists on the road about midway between Galway and Oughterard.

Viewing these rocks generally, they would appear to be of comparatively recent formation; we may, therefore, infer that, in the earlier period of the condition of the earth, circumstances were not favourable to their development, or at least to their propulsion to its surface.

Basaltic Formation as shown at Staffa

Basalt, which is the most widely-distributed stone of this class, is now acknowledged to have been produced as lava, either from submarine volcanoes (in which case, cooling under the pressure of water, it became crystallised in columnar form, and was afterwards gradually raised), or it was poured forth at a higher level in tabular masses, covering the surfaces of other rocks. This formation is of very extensive occurrence all over the globe; the greatest known mass is that noticed by Colonel Sykes, and published in the "Proceedings of the Geological Society" (London, 1833), as existing in the Deccan (India), covering many thousand square miles of surface.

On the continent of Europe, in Italy, central France, upon the banks of the Rhine, and the Cyclopean Islands in the Mediterranean, also in Iceland, and in the Hebrides (at Staffa), we find imposing examples of columnar basalt; but in no region of the globe is the majestic grandeur of the formation of the north-east coast of Antrim equalled, where, according to the accurate measurement made by the Ordnance Trigonometrical Survey, many of the columns reach as high as 317 feet, over a nearly similar depth of chalk, and the sides of these enormous prisms occasionally measure from 5 feet to 6 feet.

The stones of the Giants' Causeway, jointed concave and convex one into the other, and fitting with the utmost accuracy in their polygonal sides—within the interstices of which the blade of the smallest penknife cannot enter—are justly considered a phenomenon of nature; but visitors to this district seldom take the trouble of viewing the miles upon miles of coast-line, only seen from the

Pleaskin, the Causeway.

sea, stretching towards Belfast, where the columnar formation shows itself in heights, including the chalk beds upon which they rest, and their superincumbent capping, rising from 500 feet to 600 feet in perfectly perpendicular lines, forming the most magnificent coast-line in the world.

This stone principally occurs in Antrim and Derry, both columnar and massive; it is also found in considerable quantity in Limerick, and it is seen in some of the hills, massive, in Kildare, as well as in other inland districts.

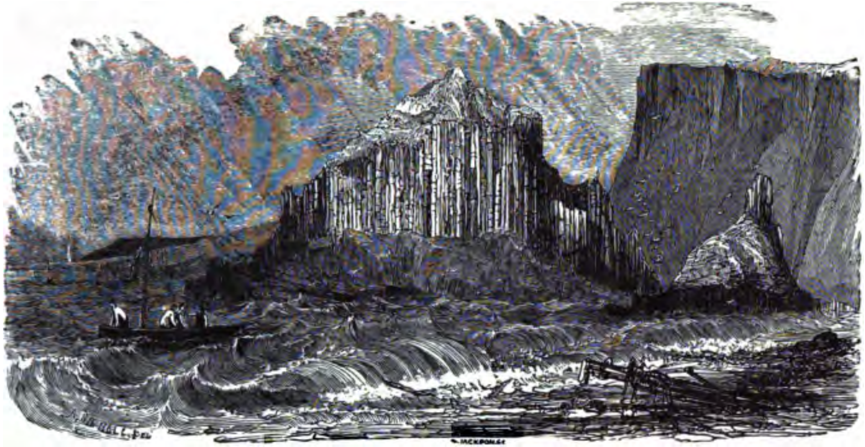
Basalt is a close, compact rock of dark green colour, nearly approaching to black; it is of variable composition, and consists principally of silica, oxide of iron, felspar, pyroxine, alumina, and lime. Silica and oxide of iron exist generally in the same proportions in it; but alumina and lime—both of which largely modify its texture, the former varying from one to six, the latter from one to nine in its quantity—alter its structure to a very considerable extent.

Lyell informs us that "many of the figures of Egyptian temples are formed of basalt;" therefore the stone from which they were sculptured must have contained alumina and lime in vastly greater proportion than occurs with us; possibly they were executed from massive not crystallised lava, as between the two there exists great variety of structure. As lava flows from a volcano, its upper surface becomes porous, but in its sediment dense, owing to the slow cooling and the pressure it becomes subjected to; frequently streams of it are poured into the sea, and the upper surface, or the foam, if so we may call it, of what is in reality a river of fire assumes this form, and is pumice stone so useful in the arts; a denser form of pumice stone occurs over cooled streams of lava, but still not so dense that it will not float upon water.

The hardened deposits of this stone differ materially, according to the mountain it is ejected from, in those of Iceland is found the glass formed by nature, "black obsidean," much used for ornamental purposes, and presenting different appearances according to the section in which it is cut and polished, at one time a full jet black, at another a glistening gray. In the lavas of Vesuvius are found beautiful crystals of olivine, or olivegreen, which tourists find manufactured into jewellery.

Striated and Polished Boulder. Slieve League, Donegal.

Greenstone, popularly called whinstone, occurs in all the clay-slate rocks, and frequently in sand-



Basaltic Columns, Giant's Causeway.

"Dark o'er the foam-white waves,
The Giant's pier the war of tempests braves,
A far projecting firm basaltic way
Of clustering columns wedged in dense array.
With skill so like, yet so surpassing art,
With such design, so just in every part,
That reason pauses, doubtful if it stands,
The work of mortal, or immortal hands."

stone; it is of volcanic formation, protruded through other rocks of sedimentary deposit, of hard, compact nature, of exceedingly close texture, and, like all rocks of its class, alters the character of other formations where it comes in contact with them It obliterates the stratified appearance of the sedimentary strata, and causes them to become crystalline. Blue limestone is occasionally converted by it into a close-grained white marble.

Erratic Block. Mourne Mountains

Rounded, water-worn masses of stone—many of diameters of twenty feet, principally of granite, but including every known formation—are found all over the country, often in such elevated positions that it is matter of surprise how they have been transported thither, because, being generally of different stone from that which occurs in the locality (although this remark does not always follow); sometimes in an exclusively limestone district we meet granite, conglomerate, sandstone, and trap rocks, lying within a few yards of each other, all rounded by attrition with other rocks.

It is from the floating power of ice we have derived these immigrants to our shores—some of them from the loftiest Alpine regions. Yet the majority are native, and often found embedded in clay deposits, some of them projecting partially above ground, others covered but by a few inches of soil, others perched on the highest mountains, while numbers are excavated at considerable depths—these are derived from the Donegal and Mourne mountains, and the Killiney and Dalkey hills, and could only have been deposited in their present position during the general glaciation of this country.

In northern latitudes enormous icebergs are constantly found floating, many of them rising some 200 feet to 300 feet above the sea level, and having much greater depth under water, in which are embedded huge rocks, clay, and gravel; and, as they float into warmer latitudes, perhaps over submerged mountains, the ice melts, and deposits this foreign matter (which may have travelled thousands of miles) at the bottom of the ocean. In after ages this ocean bed is gradually upraised, covered by numerous masses of rock. To the student in geology, Galway county offers the most interesting examples of immigrant boulders.

In our previous remarks we stated the theory that Ireland was at one period almost wholly submerged under water, and which we have explained at greater length in the chapters of Addenda, "Climatic Changes" and "The Antiquity of Man." Beds of shell covered by marl, but always found resting upon gravel, numerously occur all over the country, in basins on the slopes of hills, but more generally in valleys. These shells are univalves and bivalves, whose *habitât* is the deep sea or upon the slopes of a shore; and they have become in their present positions covered over by successive deposits of a calcareous marl, only produced by the subsidence of water holding lime and clay in solution. In many instances they are discovered under a considerable depth of bog. It is in this marl that Griffiths describes the skeletons and horns of the Irish elk being found, fine specimens of which are preserved in the Royal Dublin Society's Museum, and in the Royal College of Surgeons. This animal, whose remains have been excavated in abundance, in these deposits, appears to have been a contemporary with man, as a human skeleton has been found embedded in the marl closely adjoining one of them. Along the eastern coast of Ireland, as well as in many other portions of the country, fine sand and beds of sea-shells are found at considerable elevations above the sea level—in many instances as high as 600 feet, which is still more conclusive of the theory above given.

The sand and gravel hills of Ireland form a most valuable adjunct to building material. As Eskers they are known in every county, their substrata being beds of clay, then gravel, super-imposed by sand, frequently containing marine shells. Sometimes all these deposits appear to have been violently mixed together by some disturbing action. In the county Dublin we have examples in the Green Hills, near Tallaght, and at Ballybrack and Howth, but they occur everywhere all over the country; the great majority, however, are found in the central limestone plain, where currents became established by its gradual upraisal and denudation. These sand and gravel ridges confirm our knowledge that Ireland was, at a comparatively recent period in geological history, submerged in water; also that by its elevation and consequent subsidence of the retiring seas, when meeting with obstruction they deposited these beds of clay, gravel, and sand.

From Dr. Antisell's "Irish Geology," page 73, we extract the following:—These hills are looked upon as deposits out of diluvian currents, which swept across the country in a direction in some degree N.W. and S.E., but altered in many cases by local obstructions. It would appear that the currents were sometimes of great depth and of varying velocity, for many of the beds bear marks of violent agitation and unequal subsidence, mixing all the contents together without regularity; while in others, the evenness and succession of the beds, and the finer lying comformably upon the coarser, indicating that in the last the waters were in a state of quiescence compared to where the deposits are uneven.

CHAPTER VII.

Coal—The Mining Districts.

LOOKING back into the chronicles of nations, do we not find that the future of millions has been influenced, and the commercial prosperity of unborn peoples, determined by the slow and tranquil causes operating remote ages ago in nature; the deposits of coal converted into beds of ancient seas and lakes, and afterwards elevated as dry land, covered by layers of shale and shingle, are one of the most remarkable examples. What Ireland might have been, if creative power had permitted her to remain as she was of erst, is perhaps difficult to determine. In the history of the world mineral wealth, but more particularly coal and iron, wherever they exist in quantity, unerringly foreshadow the future of a country; for example, England's greatness must primarily be attributed to her vast resources in both; her empire, the greatest the world has yet seen, would not have been but for coal and iron. If nature had left Ireland as she once was, it is not too much to assume she would have been to her sister an auxiliary all but invaluable; that coal, at all events, existed in almost unlimited quantity in former periods of her history is abundantly proved, which no one who has studied her geological formations can doubt. We have its evidence in different parts of the island, in the existing remnants of coal fields, and it is clear from the manner in which their outcrop now presents itself that they originally extended infinitely beyond their present limits, proving to demonstration that by some violent changes they were broken off abruptly, denuded, and washed away into the adjoining seas by the overwhelming power of the ocean wave; and if anything were needed to confirm the theory of the submergence, partially or otherwise, of this island at a remote era, the denudation of its coal fields by the action of water sufficiently attest it. Professor Hull, in his "Physical Geology and Geography of Ireland," at page 153, somewhat graphically alludes to this subject, and describes the remnant of the upper carboniferous strata which have escaped destruction as "like solitary columns amid the ruins of ancient temples, monuments of the decay and waste which has reigned around."

The veins of coal throughout Ireland are comparatively of little magnitude. In the Castlecomer or Kilkenny* district there are two or three thin seams, which are extensively worked and supply a large local demand; in Tipperary there are several beds of some extent, but the seams are also thin, yet they are worked with considerable success. This remark also applies to the seams at Kanturk, in the county Cork. The Tyrone coal-field occupies a large area; it is much broken by faults, but is likely to be rendered very productive; being in a manufacturing district, it is to be hoped eventually it will become a valuable adjunct to the industries of Ulster.

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* Kilkenny coal possesses singular properties, arising from the total absence of bitumen, which, in specimens of the generality of good quality coal, as well as Whitehaven, usually amounts to 50 per cent. of

The coal-beds and mineral veins of Ireland being commercially of considerable importance, and most interesting in a geological point of view, our subject would be incomplete without the foregoing notice of them. Their extent and localities have been described in the late Sir R. Griffiths' "Outlines of Geology of Ireland," and their commercial value prominently brought forward in Sir R. Kane's "Industrial Resources," to which authorities, for information on these points, we refer our readers. Coal always occurs in seams of different thicknesses, overlaying each other; seldom horizon-

the entire; it is principally composed of carbon, and does not admit in combustion either smoke or flame. Referring to Kilkenny, part of an old rhyme runs thus:—

"Fire without smoke, earth without bog,
Water without mud, air without fog,
And streets paved with marble."

Perhaps it is to the paving with marble the absence of mud is attributed; with regard to the coal being devoid of smoke, it is perhaps a disadvantage, as it emits a peculiarly unpleasant and unwholesome vapour—carbonic acid and sulphuric acid gas.

tal, but generally inclined, as all deposited strata are found; its being of vegetable origin is unquestioned. At the period of its accumulation, that the earth was covered by rank, luxuriant vegetation, and a nearly tropical heat pervaded the entire surface, is certain, because the remains of tropical plants, such as tree-ferns, most predominate, while many of the species discovered are totally unknown at the present day, yet all evidently of tropical growth.

In the shale which separates these beds of coal, and in the sandstone accompanying them, impressions of plants are found—horse-tails and club mosses of enormous size, yet bearing evidence of being allied to the diminutive specimens existing in our climate, but of such vast proportion in their cellular structure as to prove they could only have existed in very warm latitudes. Numerous large fragments of trees are found upright, with their roots still embedded in their native soil, while many more are horizontal, as if transported from a distance.

The most probable theory accounting for coal-beds is: that they were once immense tracts of the richest vegetation, of which we have now no representatives, except upon a small scale, in the swamps of India, Africa, and South America. We have sometimes heard that our own bogs will, after the lapse of ages, be reproduced in the form of coal; but of this we must remark, when that period shall arrive they will be found greatly deficient in the properties of our present product. The luxuriant vegetation of tropical climates can only produce it, such as we are accustomed to.

But to return. These enormous fields of vegetation—the vegetation of age after age, superimposed upon each other—were, by some depressing cause, lowered until they became submerged under water. Possibly, by being thus formed into lacustrine beds, they accumulated mud and sand, the precursors of shale and grit, which formed successive strata over them. They were again upraised, similar vegetation appeared, and similar results followed.

We cannot better terminate our remarks upon the formation of coal than by giving an extract from Professor Buckland's graphic account of the coal mines of Bohemia, given in Bridgewater Treatise:—"The finest examples I have ever witnessed is that of the coal mines of Bohemia. The most elaborate imitations of living foliage upon the painted ceilings of Italian palaces bear no comparison with the beauteous profusion of extinct vegetable forms with which the galleries of these instructive coal mines are overhung. The roof is covered as with a canopy of gorgeous tapestry, enriched with festoons of most graceful foliage flung in wild irregular profusion over every portion of its surface. The effect is heightened by the contrast of the coal-black colour of these vegetables with the light groundwork of the rock to which they are attached. The spectator feels himself transported as if by enchantment, into the forests of another world. He beholds trees of forms and characters now unknown upon the surface of the earth presented to his senses almost in the beauty and vigour of their primeval life. Their scaly stems and bending branches, with their delicate apparatus of foliage, are all spread forth before him, little impaired by the lapse of countless ages, and bearing faithful records of extinct systems of vegetation which began and terminated in times of which these relics are the infallible historians."

Impression of a Fern. Coal Mines of Bohemia.

Lyell does not give the formation of coal, but, in vol. ii., "Principles of Geology," page 249, he describes the drift-wood constantly floated down large rivers into lacustrine deposits as now producing wood coal. In Ireland we have examples of this in the lignite found on the banks of Lough Neagh, at depths varying from 30 feet to 70 feet.

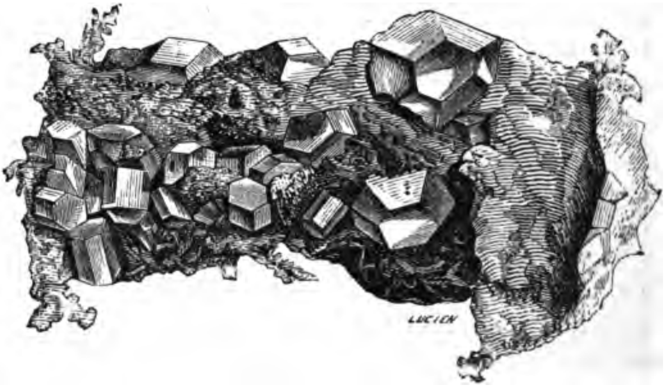
In connection with the formation of coal, it is an extraordinary fact that, no matter in what part of the world it is discovered, even at Melville Island, in the regions of eternal frost, the same tropical vegetation pervades it. This would tend to show that the climate of the entire globe was at one period uniform. This may, or may not be. Coal however, is only produced under a tropical sun.

The small remnant of the coal formation of Ireland which still exists rests upon the upper limestone, with intervening beds of sandstone and slate rocks, and the districts where it occurs have generally an aspect of considerable elevation. A glance at Sir R. Kane's "Geological Map of Ireland" will at once show where all the workable seams occur and prove the denuding forces which once existed.

Mining operations date back to a remote period. In several of the abandoned workings of former times, antique tools are found, wooden shovels, stone hammers, and chisels of primitive form, evidently of great antiquity.

Dr. Boake tells us in his "Natural History of Ireland," written more than 230 years ago, that iron was manufactured then in considerable quantity, so much so as to have been an article of considerable export to London. Iron ore exists largely in numerous places, and is found in almost every coal district. There is also what is called bog iron ore, which, as its name implies, occurs in bogs and morasses. Iron ore is also found in the sandstone and clay slate deposits.

In the clay slate, copper is obtained more or less abundantly, particularly in Wicklow, Waterford, and the southern portions of Cork and Kerry.

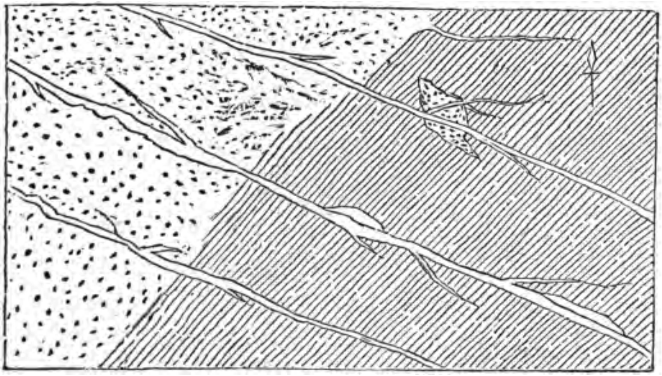


Copper Ore. Wicklow Mines.

Lead ore is extensively developed in the granite districts of Dublin and Wicklow. In Wicklow it has been extensively worked at Glendalough and Glenmalure. Near Dublin, at Ballycorus, it is found associated with silver, and at Clontarf, in the same county, in the calp formation on the sea-shore, it was for a time successfully raised, until the tide broke in and filled the mine with water.

In the clay slate deposits it occurs in Armagh, Down, and Louth, and in Clare, Cork, Kenmare, Kilkenny, Waterford, and Wexford, in the granite and mica slate of Connemara and Donegal.

Silver is generally found associated with lead in Ireland, and varies in quantity from 8 ounces to 120 ounces per ton of ore. At Kilbricken mine, in Clare, it occurs in the latter large proportion.



Veins of Lead in Granite and Sedimentary Rock, Wicklow.

That the ancient Irish must have been possessed of native gold is evidenced by the abundance of their ornaments preserved to our time, and for which no means of importation then existed. About eighty years ago considerable quantities of gold were found in the beds of the streams which descend from the mountain Croghan Kinshela, which rises on the confines of Wicklow and Wexford, where it was for a considerable time collected by the peasantry in larger and smaller nuggets, and even down to the most minute grains. The business of its extraction was at length taken up by the Government, but it was found after a while it would not pay the cost of working. About forty years ago a London company obtained a lease of the district, but the produce of gold was so trifling the works were finally abandoned. Yet it is curious to remark that, before the Government had possession of the mines, reliable information informs us a sum of £10,000* was realised by the country people who collected it.

Iron pyrites, or sulphur ore, exists in considerable quantity in the clay slate of Wicklow, and is an article of constant export.

Mr. Kinahan, in his "Manual of the Geology of Ireland," tells us that quite recently a small nugget of gold was picked up in St. Stephen's-green, Dublin, out of a load of gravel brought from the river Dodder, and he gives much interesting information with regard to both gold and silver occurring in Ireland, a portion of which we avail ourselves of:—

"That the gold in the mountains of Dublin and Wicklow was worked by the ancient Irish seems proved by the annals. One of the names by which the people of Leinster were called was Laighnigh-an-oir, or, the Lagerians of the Gold; and we are told that the king Tighernmas, or Tiernmas, who reigned about 1,000 years, B.C., was the first that smelted gold in Ireland, and that the mines were situated in the Foithre, or woody district, east of the Liffey (the Dublin mountains). The name of the artificer is said to have been Uchadan, and his residence in Fercualan, or the present barony of Powerscourt.

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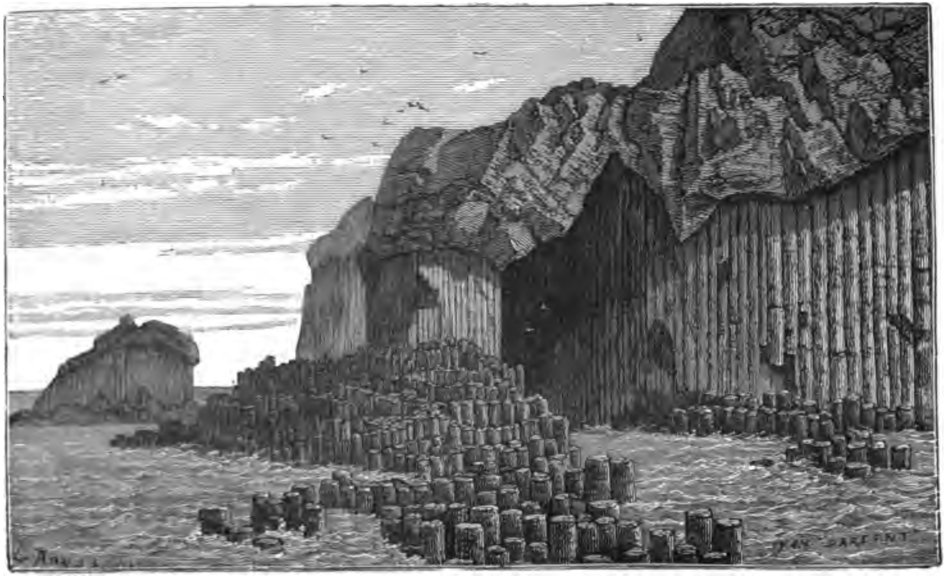
* "Industrial Resources."

"Silver similarly to gold is mentioned by the old historians. Enna Airgtheach, who reigned about eight centuries and a half, B.C., is said to have been the first who made silver shields for his chieftains. They were made at Argetros, or Silver Wood, on the Nore, county Kilkenny. In that neighbourhood, at Ballygallion and Knockadrina, are very ancient mines in which native silver associated with argentiferous lead occurs. Silver is also said to have been found near Toomavara, county of Tipperary, at a place called Rosargid, which also means Silver Wood. This name has not reached our day, but a little southward of Toomavara, at Kilanafinch, are the remains of very ancient 'silver mines,' as they are locally called."—G. H. Kinahan's "Manual of the Geology of Ireland." London, 1878.

In concluding these chapters, our only remarks shall be—we have avoided, as being unnecessary for their intended purpose, entering upon the numerous subdivisions of rock formation so minutely described by geologists. All—either primary, stratified, or volcanic—where, as they necessarily must be, in contact with each other, produce numerous hybrid variations, completely altering their relative textures, each partaking of the qualities of the other, the igneous rock becoming partly stratified, and the stratified losing the original traces of its origin. These metamorphic changes have contributed largely to subdivision, while many of the different groups derive their names from the localities in which they most abundantly crop out on the surface of the globe; others from the organic remains, either animal or vegetable, found imbedded in them; but by far the largest are classified from the age of their deposits, to which, to the beginner, a puzzling nomenclature is applied. Our purpose has been to explain in the simplest possible manner the different descriptions of mineral formation as occurring in Ireland, therefore we have confined ourselves to the principal denominations of each, avoiding as much as possible entering into minutiæ, which, in a utilitarian point of view, could have no connection with our subject. In remarking upon coal, and the mining districts, the information given is only of a general character. Both are ably treated, and in the fullest possible manner, in the works of the late Sir R. Griffiths, and Sir Robert Kane, of whose valuable labours we have availed ourselves, in addition to other acknowledged authorities. In these chapters we have had but one object in view, namely, the promotion of a taste for geological information, which many erroneously suppose is inconsistent with Divine teaching. When it is remembered that the revelations of Scripture are more generally employed in a figurative sense, the first chapter of the book of Genesis will be found only to explain the truths unfolded by science, and make apparent the dispensations by which the Almighty Architect of the Universe, in the exercise of his Divine power, has rendered this earth subservient to all the wants of man; and as each phase of geological discovery presents itself to our view, in page after page of its history, they in their turn tend the more fully in compelling us to acknowledge there is no departure in them from the words which have emanated from the Great Creator of all; and when we consider that He has permitted His creature man to exercise the genius and power of research conferred upon him in unveiling the marvellous history of bygone worlds, and enabled him to explore the far-off epochs of creation, we should admit it was not without an object: and as we must believe the earth will again undergo a cataclysm similar to the many we have described in the earlier pages of this book, it is to be hoped that the treasures of the scientific labours of our era will not be without advantage to the more highly organised races who, according to the imprints which remain to us, will probably follow as habitants of the globe; for it seems to be the law of Divine power, so far as our limited capabilities can explain it, to make each change of the world's system more perfect than those which have preceded it, and, according to the notions of Cuvier, as expressed by a modern author:—

"Such things,
Tho' rare in time, are frequent in eternity."



Fingal's Cave, Staffa.

Addenda.

DESULTORY REMARKS UPON SUBJECTS IN CONNECTION WITH GEOLOGY.

CHAPTER I.

THE DISINTEGRATION OF ROCK.

What the Earth owes to it—Effects of Frost and Thaw—The Erosive Power of Running Water—The Sea, and its Agencies—Chemical Decomposition of Rock—Formation of new Land—The Earthquake and the Volcano—The Cliffs of Moher—The Giant's Causeway.

THE disintegration of rock forms a most interesting feature in geological study, and to its action we owe the production of the various soils which cover the surface of the globe, and the vegetation which clothes it. In the primary stages of the condition of the earth there could have been neither "flora nor fauna," as clay, sand, or mould did not exist until formed by the gradual or violent wearing away of rock. Therefore it is to this influence we are indebted for all the varieties of soil, and the different formations of deposited strata, which, although originally of igneous origin, now constitute by far the larger proportion of the mineral kingdom of the earth; and solely to this source also for all that is picturesque and beautiful in nature—for the primeval forest, the wooded upland, the depths of the tangled gorge, the jutting cliff, and the fairy dell—the undulating surface of the grassy turf, the sylvan scene with its velvet sward, and the countless myriads of flowers in all their brilliant array of vivid and varied tints, which combine in producing the pleasure to be derived from the beauties and sublimities of a surrounding landscape. What does the little pebble you pick up on the sea-shore tell you of?—the fragment of once, perhaps, a giant rock, borne it may be, thousands of miles, embedded in an iceberg, to our shores, but now rounded by attrition during numberless years into its present form; or the piece of water-worn shale which you find in the tiny streamlet, and in which embedded is the impression of a fern, and you can almost imagine it as identical with existing species, or a sigillaria presenting a foreign aspect, yet both bearing evidence of their tropical growth in a former world. Without disintegration of rock, this earth would be a barren, lifeless waste—a scene of fearful jagged acclivities and yawning chasms, such as the moon is now revealed to us by telescopic power, without a patch of verdure to relieve the eye, a rounded outline, or a single feature of interest except massive rock—twisted and contorted, it might be, into various shapes.

How much, then, should we admire this benevolent ordination of the Author of our world's being! This destroying agency, created by Him for reproductive purposes, in the most extended and utilitarian signification of that term, is more particularly apparent in regions of perpetual frost. The tourist, in his first experience of Alpine travel, standing amid a world of glaciers, is astonished beyond measure in witnessing the wide-spread mineral ruin which surrounds him; stones of every form and size are flung around in the utmost conceivable variety of wild irregular profusion—as in the early part of the summer season they are constantly toppling over into the mountain torrent, and hurled away unceasingly in its foaming waters, and, as the sun gains power, the phenomenon increases in proportion. But, after all, these are only feeble representations of what is occurring day after day in the glacier regions of Asia and America. Water, freezing in the interstices of rock and in its veins and pores, acts like so many innumerable wedges, separating it generally in giant masses, upon the occasion of the first thaw, and then into smaller fragments, until at length falling asunder, they are borne away in the icy stream; and the rattling noise which they produce is often deafening as, hurled over cataract and fall, they are dashed to pieces and split into a variety of shapes, particle by particle, as on and on continuously they are hurried, until finally they are nearly reduced to grit, only to be further decomposed by the numerous rills set in motion by the increasing warmth of the summer sun. Thus they are converted into shingle, sand, and mud, either to form deltas and arable land at lower levels, or to be deposited in the bed of the ocean, and cover over the marine formations of past periods, only to be reproduced in future ages when upheaved again as rock.

The erosive power of water in producing disintegration of mineral matter is exemplified in rivers excavating their courses through rock, and arises from two causes—the one chemical, because springs emanating from limestone districts, and flowing into rivers are depositories of carbonic acid, and they will thus dissolve even silica, the hardest formation; the other is mechanical, as where falls occur, abrasion is in constant action; still this abrasion is considerably augmented by the chemical effect of the carbonic acid held in combination with the water.

We have it upon the authority of Lyell that the Falls of Niagara are receding at the rate of one and one-third yard annually, and it is to be supposed that all rivers in mountain districts, according to their volume, are in like proportion thus disintegrating the rock through which their courses lie. It will, therefore, be apparent that a large proportion of the earth's surface is continuously wearing away unnoticed before us.

The destructive power of the sea is well shown on the south-west and west coasts of Ireland, in the decomposition and in the excavation of its hardest rock. The Skellig Islands (the largest of which lies about eight miles south of the nearest point of Valentia) are exposed to all the wild fury and foam of the Atlantic, by which they are worn away into giant pyramids. The greater Skellig is described as a stupendous mass of slate rock rising majestically from the sea, and at the height of fifty or sixty yards, dividing into two pyramidical summits, of which the larger has an elevation of 1,500 feet above high-water mark. At Ballybunion, on the coast of Kerry,* numerous caverns are eaten into the cliff-bound shore; one of these in particular runs a considerable distance inland, parallel to the coast line, through which are arched openings primarily formed by the surf excavating on and on; thus it has formed a passage which permits boats to pass from one to the other. Some of these caverns are fully sixty feet in height. On the same coast, close by, the Devil's Castle stands an enormous isolated pillar of rock, resting upon a narrow base, and looking like a huge obelisk casting its shadow upon the waters which surround it. These examples are much out of the way of ordinary tourist travel, and are, therefore, little known. On a calm summer day the sail from Valentia Island to the greater Skellig is one of the most delightful of trips, an ever-varying panorama of sea and rock, the more beautiful because tinted by nature's hand, presenting itself throughout. The caves of Ballybunion are easily reached by car from the neighbouring town of Listowel, and, when the tide is at the full, accessible by boat without difficulty.

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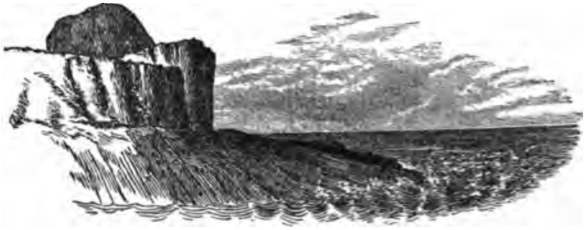
* One of the indentations of the cliffs of Ballybunion is called Smugglers' Bay, and from a little volume, published by William Ainsworth, Esq., in 1834, we extract the following:—"The cliffs of Ballybunion are even less remarkable for their dimensions than they are for their singular form of rocks, which seem as if carved by the hand of man, and independently of the lofty mural precipices whose angular proportions present every variety of arrangement, as in Smugglers' Bay, where they oftentimes are semicircularly arranged like the groin work of an arch, or the tablets or small strings running round a window, or are piled above one another in regular succession presenting a geological phenomenon of great grandeur and magnificence."



Erosive action of the Sea, Coast of Kerry. A Volcanic Bomb.

At Miltown Malbay, in Clare, similar appearances present themselves: one of these—the well known Puffing Hole—an extraordinary freak of nature, where the tide is driven through a cavern worn by the action of the surf, until at length it has obtained an outlet upwards, producing a beautiful fall, reflecting, when the sun shines, the shades of the many-tinted iris.

Underneath the cliffs of Mohir, which arise perpendicularly nearly 1,000 feet over the waters of the Atlantic, disintegration of rock by the action of the sea is well shown, and also on the coast of Mayo, where innumerable caves are to be seen, some of them stretching hundreds of yards under the superincumbent rock, but far more

Fhir Leith, excavated by the Sea, amid Basaltic Columns.
Coast of Antrim.

picturesque at numerous points on the coast of Antrim. The majestic promontory of Bengore, or Fair Head, is, without exception, the most sublime of nature's creations, and decidedly is not equalled in the world, rising to the stupendous height of 636 feet above the sea; its base is one wide-spread mass of ruin, as if gigantic temples had been overthrown by some devastating power upon the shoreline beneath, which is crowded by the debris of its columnar construction, looking like the work of man's art suddenly arrested in its progress, and confusedly scattered by the encroachments of the wild surges of the northern ocean; huge cliffs, pinnacled and isolated by the ever-recurring surf, stand out in bold relief under stupendous masses of columnar basalt for miles along at either side; several immense caverns are formed in the chalk

Grace Staples' Cave.

Fair Head.

preceding notes that few tourists to the Causeway take the trouble of viewing the shore-line; therefore, as a rule, they are disappointed, because they never see its magnificently picturesque adjuncts.

The Chasm, Carig-a ramhad, Antrim.

On the east and south coasts of England, the sea is constantly wearing away its cliffs, but nowhere in the British Islands is its decomposing power so well exemplified as in the Orkneys and Shetlands, for there innumerable gigantic masses of rock are perfectly isolated from each other, still showing they once formed a continuous mass, and looking in their desolation like weird spectres, sometimes likened to a small fleet at sea,* as standing out in bold relief mere skeletons detached in shreds and patches, they seem still striving vainly to oppose themselves to the fury of the ocean.

But nature has adopted other and less violent means for the disintegration of rock; these are exclusively chemical, but are equally effective as destroying agencies. There are many rocks which contain metallic veins, properly called sulphurets, which by the gradual absorption of oxygen from the atmosphere, are converted into sulphates, and which are not alone soluble in water, as we often see by the discoloration of mountain springs, but many of them, when exposed to the atmosphere, absorb moisture to a considerable extent; these, as a matter of course, become speedily decomposed. For example, felspar, one of the constituent parts of granite, being a silicate of alumina and potash (which latter has a considerable tendency to absorb water), is thus easily disintegrated; so also are all the rocks which contain silicates of alkaline bases —even quartz, one of the hardest formations, is sensibly affected by water holding carbonic acid. Where iron exists, decomposition must be in action so soon as ever the stone is subjected to atmospheric influence; therefore, it is not surprising, that both igneous matter and deposited strata holding metallic substances in combination are gradually and constantly wearing away from the oxidisation of their constituent parts.

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* Milner's "Gallery of Geography."

But the Author of the universe has not made laws for its government which contain within themselves elements of destruction, without ordaining corresponding compensating power; these have been from the beginning, and will be, according to our necessarily limited experiences of the past, continuous throughout time; for, although the agencies we have described are ceaseless, renovation is co-existent and simultaneous with their progress. New continents and new islands are forming themselves in the bed of the ocean, but to be upraised in future conditions of the earth. Where the shore-line is decreasing upon some coasts, it is increasing upon others. Before our eyes the innumerable class of zoophytes are building up land in coral formation from the depths of the ocean, something akin to the chalk and oolite structure of former periods. Volcanic action is elevating it in different quarters of the globe; but man's little term here upon this earth comparatively with its existence, has scarcely yet unfolded to him all the unchangeable perfection of the works of his Maker. There is no such thing as destruction, properly so called, existent—renovation and regeneration are unceasing upon the

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* The hills of Devon and the mountains of Derbyshire are principally of coral formation.

Disintegration of Rock, coast of Antrim.

surface of our planet, so that it may be fairly said it is in the enjoyment of perpetual youth.

From all this it would be apparent the earth is in constant state of change, ever renewing itself by the most ordinary and familiar operations of nature, either by the intense cold of the Arctic regions alternating tardily with the remote gleam of a short summer sun as it floats the iceberg into warmer latitudes, or as it splits up rock to be borne down upon numerous streams but to be reduced to sand and mud; or in the more temperate climates by the sunshine and the shower, with occasional paroxysms of storm accompanied by pelting, driving rain acting in conjunction with its chemical allies; or the earthquake, and the volcano with its desolating power while in action, and then in its periods of repose when new soil forms upon its streams of lava, or over its accumulated depths of scoriæ and ashes which have destroyed all traces of long-lost peoples, their arts and industries, or it may be the huts of the more savage denizens of the earth, or the temples and palaces of the most refined colonists of their age, only to be discovered by accident after the lapse of many centuries, as the latter have been in Pompeii and Herculaneum.*

Much more might be written upon, and more numerous examples given of, the disintegration of rock, but enough has been shown to prove that very many agencies are in action for this purpose. We have described the mechanical forces which produce it, from our own observation, assisted by the authorities quoted; but the chemical causes adduced are derived from Fowndes's "Chemistry," London, 1872, as well as from other standard authors, but to the first of which we acknowledge ourselves principally indebted.

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* The mounds of Assyria, which in the early summer teem with verdure and flowers of countless hues, hiding away all traces of the ruins of Nineveh and Babylon, and looking like hill and dale of ordinary landscape, are graphically described by Layard as studded profusely with the "myrtle, the ilex, and the oleander" in their richest foliage, and flourishing luxuriantly in the soil which has accumulated

during the lapse of centuries over the earliest cities of the human race, are not perhaps strictly applicable to our subject, except so far as evidencing the wonderful renovating powers constantly in action on this earth.

NOTE.—In Chap. I. of "Outlines of Geology and Geological Notes of Ireland," we have stated that, at a remote period in geological history, Ireland consisted of a series of islands. In confirmation of these remarks we give the following extract from Sir Charles Lyell's Fourth Edition of the "Antiquity of Man," London, 1873:—

"The signs of glacial action have been traced by Professor Jukes to elevation of 2,500 feet in the Killarney district, and to great heights in other mountainous regions. Marine shells have rarely been met with higher than 300 feet above the sea, and that chiefly in gravel, clay, and sand in Wicklow and Wexford; but in one instance, near the Three Rock Mountain, S.E. of Dublin, marine drift containing fragments of cyprina and glacial shells, reaches a height of from 1,000 to 1,200 feet. More than eighty species have been obtained from these marine drifts. The great elevation of these shells, and the still greater height to which the rocks in the mountainous regions of Ireland have been smoothed and striated, has led geologists to the opinion that that island was in a great part submerged during a portion of the glacial period, and the wide extent of drift spread over large areas in Ireland seem to indicate that the land above water formed an archipelago."

CHAPTER II.

THE ANTIQUITY OF THE EARTH.

Comparatively recent Creation of Man—Opinions of Grecian Writers—Time required for the Formation of Stratified Rocks—Age of Coal Deposits—Erosion of the Falls of Niagara.

THE age of this earth is a subject which, from the earliest periods of civilisation, has been a mystery to mankind. From Egyptian teachings to those of Pythagoras, Aristotle, Strabo, and Pliny, down to our own time, it is still a puzzle, and will so continue for ever. Ages ago, and even until a recent period, both the Jew and the Christian have considered inquiries of this description as rank impiety; but modern intellectual development has dissolved these erroneous ideas, and with them their prejudices—only to confirm us the more fully that science and revealed truths are in perfect harmony with each other. We have cumulative evidence, written in the most indelible type by the Author of our being in the fossil remains found embedded in the older rocks, that man's existence is but as yesterday in comparison with them; and we have further the direct testimony that no traces of man or his works are proven to be found elsewhere than in the alluvial and diluvial deposits, which are believed with great probability to have been formed since he became a denizen upon this earth. No signs whatever of him are discoverable in the most recent depositions of the limestone, sandstone, or slate rocks; therefore, that the age of the earth dates back for incalculable periods before man was called into being, is now acknowledged as uncontroverted fact.

The views of the ancient philosophers, although not going the length of modern geological teaching, recognise several destructions of the earth's surface, previous to the creation of man; they consider it was subjected to repeated changes, which, as we infer from their writings, were of periodical or gradual character; and they lead us to imagine that they believed the present agencies operating in nature as sufficient to produce, without total annihilation of the animal and vegetable kingdom, the numerous alterations in the disposition of land and water, which are palpably shown as occurring at very many former periods of its history. However this may be, they are sufficiently near to indicate they agree in general terms with the theory advanced by modern science.

By far the larger proportion of the material which constitute the surface of the earth is composed of deposited layers called strata, and known to have been produced under water, because many of them are but accumulations of both marine and fresh-water shells, upon a scale so vast that the bare idea of computing the time such deposits would be formed in is not within the reach of human knowledge. Each of these layers is comparatively thin, and heaped upon each other according to the time of their deposition. Sometimes we find streams of lava which have flowed over rocks of older date, but to be again covered by similar deposits, as described above. Were it in our power to calculate the time necessary to form one layer of these stratified rocks, and when we know these layers are innumerable, it is evident that it is more than the mind of man will ever arrive at to fix the period of elapsed time since this earth was first launched into space by its Creator.

Again, we have coal; and to the inhabitants of these islands it is one of the most familiar products of nature, but amongst the millions who behold it in constant use, few inquire how it has been produced. Coal, then, is a series of beds of entirely vegetable growth, which have accumulated for ages under a high temperature in swamps and morasses, and most likely becoming beds of lacustrine formation. Deposits of shale and sandstone were formed over them; being upraised by volcanic action, they became chemically altered, and mineralised in their present form. This process was again and again repeated, until the thickness of many coal fields average from fifty to sixty feet, varying in their seams from a few inches in depth to six feet, alternating often with double the quantity of sandstone and shale in intermediate beds. That this is its origin is abundantly proved by the numerous remains and impressions of plants found in connexion with it, showing their traces of organisation still perfectly distinguishable. It is remarkable that ferns most predominate, from the tree fern of tropical regions to the most diminutive specimen of the tribe; but this is accounted for by the fact that their fibres and tissues are much less easily decomposed in water and in damp than those of all other plants. The great body of a coal seam may, therefore, be composed of other vegetable matter, but which has not been preserved in its original form, as the ferns are; and it sometimes occurs that whole forests are found with their stems standing perpendicular, and their roots still embedded in their native soil,* as in the coal mines of Bohemia.

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* In Hugh Miller's "First Impressions of England and its people" (page 223), we find the following as referring to a colliery near Wolverhampton:—"The bottom coal rises to view, and where the surface has been cleared of the alluvial covering it presents the appearance of a moor, upon which a full-grown fir wood had been cut down a few months before, and only leaving the stumps behind. Stump rises beside stump, to the number of seventy-three in all; the thickly-clinging roots strike out on every side into what seems once to have been vegetable mould, but now exists as an indurated brownish-coloured shale. Many trunks, sorely flattened, lie recumbent on the coal; several are full thirty feet in length, while some of the larger stumps measure rather more than two feet in diameter. There lie thick around, stigmariæ, lepidodendra, calamitis, and fragments of ulodendra; and yet, with all the assistance these lent, the seam of coal formed by this ancient forest, does not exceed five inches in thickness. Not a few of the stumps in this area are evidently water-worn; the prostrate forest had been submerged, and molluscs lived and fishes swam over it. This upper forest is underlaid by a second, and even a third; we find three full-grown forests packed up in a depth of not more than twelve feet."

There is no product on the face of this earth which leads the mind farther back into immeasurable time than coal-fields do. Its formations are probably anterior to the existence of animal life, the fossil remains of which are preserved in our earliest strata, and may be coeval with the primary flora of the earth.

The lapse of countless ages can alone explain such phenomena, but there are many who, not doubting for an instant that the Great Creator of the Universe has existed from eternity, yet reject the theory thus given of the age of the earth, limiting it to the short annals accessible to the human race; but it is to be borne in mind that revelation was given not to inculcate physical science, but to teach man the wondrous works of God, and the immortality he was destined for. It is superstition not religion which causes the non-belief of these evidences which the Almighty has so plainly written in the Book of Nature, and which He allows man to avail himself of upon this earth in order to teach His unbounded power and make manifest His existence from all eternity.

In conclusion of this chapter we will refer to a data given by the first authority of our day, and which, to some extent, affords an idea of the age of the earth. In the fossils embedded in its earlier strata, the bones of the Mastodon,* the great prototype of the elephant, frequently occur; and Sir Charles Lyell, in his recent edition of "The Antiquity of Man," and extracted from his travels in America, referring to the remains of one discovered in the former bed of the St. Lawrence river, Falls of Niagara, thus writes:—"But in the case of the valley of the Niagara we happen to have a measure of time which is wanting in other localities, namely, the test afforded by the recession of the Falls—an operation still in progress, by which the deep ravine of the Niagara, seven miles long, between Queenstown and Goat Island, has been hollowed out. This ravine is not only post glacial, but also posterior in date to the fluviatile and Mastodon-bearing beds. The individual, therefore, found fossil near Goat Island flourished before the gradual excavation of the deep and long chasm, and we must reckon its antiquity not by thousands, but by tens of thousands of years, if I have correctly estimated the minimum of time required for the erosion of that great ravine."

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* "The remains of the Mastodon are found abundantly in the third and fourth or Pliocence divisions of the Tertiary fresh-water deposits. Also, but less frequently, in the deposits of the second or Miocence period."—*Knight's Cyclopædia.*

The earth had already undergone many and long periods of geological changes before the Mastodon first appeared upon it; therefore, the opinion of the eminent authority we have given ought to bring to every thinking mind the overwhelming conviction of its vast antiquity, which many calculate, not by tens of thousands, but by hundreds of thousands* of years. However this may be, we cannot but feel assured, from the imprint of its own unerring records, that it has existed for almost indefinite time, during which it was repeatedly destroyed and its surface as often revivified; and we must believe, when man's appointed time is fulfilled, another destruction will most assuredly follow, when—

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* Maclaren's "Geology of Fife and the Lothians."

> "The cloud-capt towers, the gorgeous palaces,
> The solemn temples, the great globe itself—
> Yea, all that it inherits, shall dissolve,
> And, like an unsubstantial pageant faded,
> Leave not a wreck behind."

But, probably, not as Shakspeare implies, will it be annihilated, as all our experiences of its past history teach the contrary. Man and his works will necessarily be entombed together with the "fauna and flora" of his age; but, if we are to trust in the permanency of the laws which to our time have governed the globe, it is not too much to imagine that, after a period of repose, a new flora will clothe the earth, and that new races of organic life will be created, to be presided over by beings of far higher order than man in all his pride and power of intellectual development can ever boast of.

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CHAPTER III.

CLIMATIC CHANGES OF THE EARTH.

The Glacial and Interglacial Periods.

MODERN scientific discoveries have satisfactorily proved that in past ages the climate of all Northern Europe, Northern America, and Asia, has been subjected to repeated change. Trees once flourished where glaciers have now invaded parts of Greenland, coal is found in quantity in Melville Island, and fossil elephants' tusks (preserved in frozen soil for innumerable ages) form a marketable product in Siberia. In Europe at one time a sea of ice of such magnitude existed, that the glaciers of Scandinavia were in connection with those of Scotland, England, and Ireland, and this mighty "*mers de glace*" actually obliterated the Hebrides and all the smaller northern islands. Such a scene of Arctic panorama now only is witnessed in the Polar regions; but gradually it changed until the temperature became milder, and yet more mild, and at length a southern, almost tropical summer pervaded perenially and for ages throughout these islands. The lion, the tiger, the hyena, the elephant, and the hippopotamus became acclimatised in Britain, which was at this period united to the Continent (and by this means they migrated thither), where the Straits of Dover now separate them. Long, long periods then elapsed, the summer sun declined in its warmth, the winters grew more severe, the existing mammalia either emigrated southwards, or died out from the increasing cold, and in lapse of time, as glacial temperature prevailed, were succeeded by the Polar bear, the reindeer, and other Arctic animals. Once more these islands were formed into a sea of ice and snow. How many of these climatic changes occurred is not within present geological knowledge; but at least one more mild interglacial period supervened, when the sea slowly gained upon the land, until the greater portion of Great Britain and Ireland was submerged under its influences. Gradually the land was partially re-elevated, and after another period clothed as before with a hoar mantle of ice, until it was once more united by a frozen sea with the Arctic regions. Again, the temperature becoming more mild, the glaciers diminish, and their places are occupied by the sea, until they exist only in mountain hollows and glens, the land at this period is slowly being re-elevated, and the moving masses of floating ice are kept continuously grinding, rubbing, and polishing the giant masses of rock over which they are kept in motion by the process of thaw, thus producing the *roches moutonnées*, and the grooves and striations, which are observable in mountain regions, these enormous rafts of ice holding within themselves innumerable blocks of boulder rock, carrying with them their own graving tools, striating and polishing as they slowly move along. And how are all these climatic changes proven to be true may well be asked. Simply by the existing animal remains discovered in bone caves, and by fossils in numerous places throughout the British Islands. The elephant, the lion, and the tiger could not exist in an Arctic climate, no more than the Polar bear, the reindeer, and the moose deer could in a southern. Yet these all occur in different deposits. The seams of coal which pervade these islands could not have been produced unless under a tropical sun, and millions of tons of Arctic shells could only have been deposited near the summits of the highest mountains by natural agencies. Therefore, all these tell their own tale, and explain away what otherwise would be unintelligible.

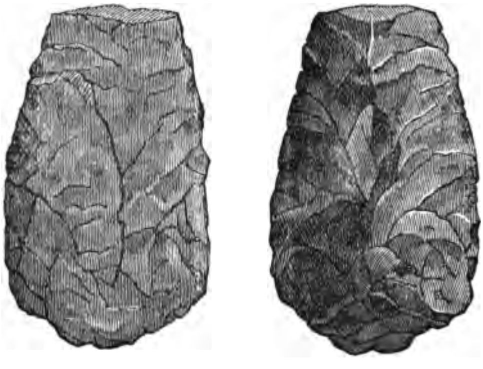
The glacial and interglacial periods—which must have lasted for unknown ages, of which no computation of time can possibly be made, form the most interesting epochs in the history of this earth—the evidences regarding them must, as a matter of course, be altogether circumstantial; but modern discovery in cave deposits, &c., has, however, unveiled what would otherwise appear deeply mysterious—almost incredible—and has tended to dispel all doubt with regard to these eventful ages. We have endeavoured, perhaps too summarily, to relate them, and in doing so we acknowledge ourselves indebted to Lyell's "Antiquity of Man," Geikie's "Great Ice Age," Croll's "Climate and Time," and Lyell's "Geology," for the information conveyed in this chapter.

CHAPTER IV.

THE SUPPOSED ANTIQUITY OF MAN.

The Glacial and Interglacial Periods—Barbaric Man—Flint and Stone Implements—The Palæolithic and Neolithic Ages—Modern Authors' opinions of the Antiquity of Man—The Skeleton of Mentone—Desultory Thoughts.

A RECAPITULATION of some of the remarks we have made in the last chapter may not prove uninteresting, because they have a direct bearing upon the antiquity of our race. In it we have endeavoured to describe the vast, almost incredible, physical changes which have taken place during far-off ages in the geological condition of Great Britain and Ireland, as well as parts of Continental Europe; and how these islands were more than once united to the North Polar regions by one vast sheet of ice, presenting a treeless scene of Arctic sterility; at another period joined to and forming a portion of the Continent—the whole enjoying a genial, temperate, and perpetual summer, and again, a nearly tropical clime; then submerged beneath the ocean wave, and converted into clusters of small islands, formed by the principal mountain tops, where the waters of the Atlantic and the German Ocean dashed wildly against their summits, or placidly laved elevated table-lands at the height of considerably over one thousand feet above the present sea level. Again, the scene changing, Arctic temperature once more prevailed; and again they are enveloped in one continuous frozen mantle; then, gradually, the climate ameliorated, and at length the temperate region they now exist in was called into being. What induced these changes is not our purpose now to enter upon, further than that astronomy reveals the position of our hemisphere was in these ages so placed by Almighty power with regard to the sun as to confer upon it a most intensely severe climate, and *vice versâ*.



Flint Hatchets.

Records innumerable exist to prove that when man first became a denizen of European countries, he existed in the depths of barbarism: he fashioned his tools and implements of flint in the rudest possible manner, and he knew no other material which he could convert to his use, either to supply his daily wants or utilise as weapons of defence. This period is called the Palæolithic, or old stone age, in contradistinction to the Neolithic, or new stone age, when man, who although he still remained in a state of barbarism, had learned to apply a higher finish to, and even to polish his stone implements. Hatchets, chisels, and knives, made of flint and stone, belonging to these primitive races, occur numerously in river and cave deposits all over England, Scotland, and Ireland, more particularly in the latter; and it is singular many of these are found embedded beneath, and often in close contiguity with the fossil bones of both Arctic and Tropical carnivora and herbivora. In a few instances human bones have been discovered in England and in Wales with these remains but the flint and stone implements very generally, tending to show that man was contemporary with the former animal habitants of these islands. Geologists therefore assume that the antiquity of the human race is greater than is generally supposed. We will not enter upon this question, but only remark that unless these animals, denizens of such widely different zones, lived and died in the land, their remains, and those of others now extinct, could not be entombed in the situations they are found in. Where the bones of man and his works occur in conjunction with them, it does not appear unreasonable to think he lived and flourished amongst them. Mr. James Geikie, in his "Great Ice Age," goes so far as to state, that man has witnessed all the great geological changes we have described as occurring in these islands.

The Jardin des Plantes, at Paris, contains perhaps the most interesting memorial of humanity in existence. It is the skeleton of a man, nearly perfect, and in a fair state of preservation, which was discovered in March, 1872, by Dr. Rivière, in a cave at Mentone, in the south of France. It is that of an ordinary-sized human being; the skull is covered with a number of perforated marine shells, and twenty-two of the smaller teeth of the stag, which you are informed, once probably was a chaplet round his head. A bone instrument lies across the forehead, and the teeth are greatly worn, as if from chewing hard food—as is observed in modern savage races. The attitude he was found in, according to Lyell, indicates he died in his sleep. Numerous unpolished flint instruments were found with him, and in the soil above lay numerous remains of animals of cold, tropical, and temperate climates; but we will give the late Sir Charles Lyell's description from Dr Rivière's own account:—"One of the most interesting discoveries of late years of the remains of man, together with flint implements and the bones of extinct animals, was made in March, 1872, by Dr. Rivière, in a cave at Mentone, in the south of France. While Dr. Rivière was engaged in a scientific mission, for the exploration of the well-known quarries and caverns near Nice and Mentone, he found *in situ*, in a cave, called La Barma du Cavillon, on the Italian frontier, the bones of a human foot. He immediately began a careful excavation around the remains, and after eight days' labour, disclosed an entire human skeleton, at a depth of twenty feet. The cavern is a triangular slit in the rock, about thirty feet wide at the base, and from sixty to eighty feet in height, and extending from south to north without any marked curvature, forty-five feet into the cliff; from its form and dimensions the full daylight reaches to the inner end, and thus enabled Dr. Rivière to have an excellent photograph taken *in situ*. The body lay in the longitudinal direction of the cavern, about twenty-four feet from the entrance. Surrounding and above it were fifty unpolished flint flakes and scrapers and a fragment of a skewer about six inches long.* Mr. Pengelly, whose opinion, from his long experience in Brixham and Kent caverns, is of great value, visited Mentone a few weeks after the skeleton was removed. The exploration was still going on, and he saw 300 flint implements, all unpolished, which had lately been exhumed. 'There was no metal,' he says, 'found in the cavern, nor was there any pottery nor any polished flint implements.'"†

Sir Charles Lyell goes on to enumerate by their scientific appellations, the different fossil remains superincumbent in the soil over this skeleton, and, as we translate them, they are the ox, the bear, the tiger, the hyena, the rhinoceros, the wolf, the stag, and a multitude of other smaller animals.

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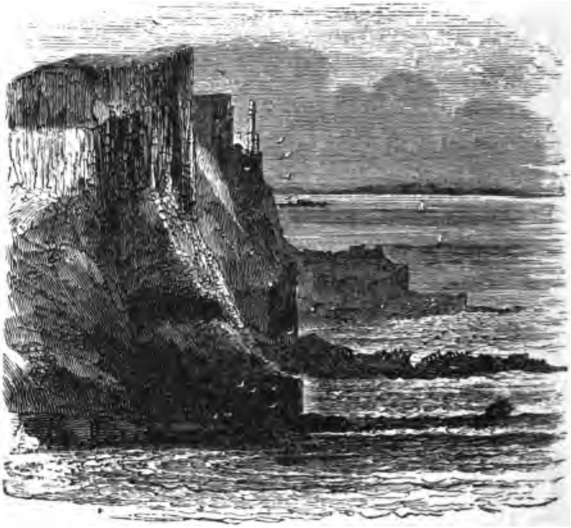
* Comptes Rendus de l'Acad. des Sciences, Avril 29, 1872.

† Journal of London Institution, vol. iii., No. 18.

It is in former river-beds, and banks of rivers whose courses have been changed, and in caves, that these remains are more frequently found—though sometimes discovered in gravel, under an enormous depth of peat. The caves are known to be part of the courses of subterranean rivers, and to have been originally formed by the continuous action of water holding carbonic acid in solution—rivers rushed through them—and may it not have been that devastating floods have gathered together and enveloped in one heterogeneous mass the memorials of man and of animal life of widely different and differing races and periods? The man of Mentone may have died upon the spot where he was found by Dr. Rivière, and his remains might have been afterwards entombed in alluviam, which carried with it the records of life which preceded him, and which possibly existed thousands and thousands of years before his time.

We know such opinions as these differ widely from many who have made this subject their study; therefore we must leave our readers to draw their own conclusions from the evidences we have laid before them.

Were we to place implicit reliance upon the theories so ably advanced by modern authors, we must believe that man's period here on earth dates back very many thousands of years further than the date we have of his existence. It is sometimes difficult, but never impossible, to reconcile the discoveries of science with revealed religion. In our writing it has always been our endeavour to do so, and we have no doubt that all who study this subject dispassionately will agree with us in thinking it is far better to attribute to natural causes, and causes within easy interpretation, the supposed great antiquity of the human race, which, after all, no one has ever yet proven.



The Chimney Tops. ***Vide*** **Coast of Antrim, page 66.**

CHAPTER V.

CENTRAL FIRES OF THE EARTH.

Volcanoes—Geysers—Temperature of Mines—Artesian Wells—Heat of Lava—Fusing of Basalt and Granite—Metals fused at Pompeii.

IN an earlier chapter we have given the modern geological theory, "that the earth was once a fluid mass in a state of igneous fusion." Lyell does not exactly agree with this hypothesis, but after all gives no valid reason for disputing it. It is certainly a simple and most probable explanation of the original formation of rock, which teaches us how, from the basis of plutonic or igneous material, all our deposited strata have been produced, and it is now generally accepted by all authorities in geology. No doubt differences of opinion must occasionally arise in the teachings of a science whose evidences are altogether circumstantial; however, it is now admitted by all that a fluid mass in the highest state of incandescence occupies the entire centre of our earth; abandoning all theory on the subject, we will endeavour to arrive at the domain of fact. Among the wondrous works of our Creator,no exhibition of His power is more manifest, or is calculated to inspire us with more reverence and awe than an active volcano. The first of these burning mountains of which we have tradition or history exists in one of the Lipari islands in the Mediterranean, and derives its name from the heathen god, Vulcan, the Tubal Cain of Scripture, of which the cognomen Vulcan is but a corruption, and who, it was supposed, after deification, set up his forges in the heart of the mountain. It is to this island and to this mountain Dryden's translation of a passage in the Æneid of Virgil refers:—

"Sacred to Vulcan's name an isle there lay,
Betwixt Sicilia's shores and Lipare,
Raised high on smoking rocks and deep below,
In hollow caves the fires of Etna glow.
The Cyclops here their heavy hammers deal;
Loud strokes and hissings of tormented steel
Are heard around—the boiling waters roar,
And smoky flames through fuming tunnels soar."

Now, all volcanoes, when in a state of activity, pour forth apparent smoke, which is in reality but clouds of infinitesimal dust, and apparent flame, which is only the glare of the seething masses boiling in their craters. It is no wonder, then, that the first burning mountain of which we have records should be ascribed to a sort of supernatural agency. It would be unnecessary for our purpose to enter into the history of volcanoes generally; but whence comes their forces but from central fire contained in the interior of the earth?

Geysers, or boiling springs, are too well known to need description here: from the Arctic regions, north and south, to the milder climates of the world, they occur with greater or less degrees of intensity of heat—from water ejected in boiling steam to the milder thermal spring. In all mining operations it is certain that, according to the amount of descent the temperature increases upon an average of about one degree in every 100 feet, being greater or less according to the conducting or non-conducting powers of the material bored through; but we have in artesian wells, now so numerous, a fair data to judge by. The waters of the wells of Grenelle and Passy, rising through borings of about 1,800 feet in depth, are, when reaching the surface, some thirty degrees warmer than the climate of Paris; therefore, whence does this difference of temperature arise? There is but one answer—the great central heat of the earth. But more convincing proofs are to be had from modern observations of the lavas ejected by Vesuvius, as given in the following extract from Mr. Davis's "Underground World," Nelson and Sons, Edinburgh, 1878:—

"But another and still more important geological phenomenon proves beyond the possibility of confutation the existence in the interior of the globe of a temperature which cannot be less than 2,732° F. Numerous observations made during the eruptions of Vesuvius have shown that the lavas ejected from its crater, and distributed over its declivities, possess an almost incredible intensity of heat. Cast into the slowly-flowing lava some pieces of glass, or even of harder substances, such as basalt, or even granite, and you will find that they fuse immediately on coming in contact with it. Frequently, in the interesting excavations which have been conducted at Pompeii, bars and fragments of iron, curtain rings and the like, as well as gold and silver coins, have been discovered in a semi-molten condition, having been liquified by the action of the volcanic ashes. As the fusing point of iron is about 2,032° F., this single fact demonstrates that the temperature of the interior of our globe cannot be less. We repeat these details in reply to an objection sometimes put forward, that no direct experiments made in the terrestrial strata have shown a higher temperature than 86° to 104° F."

After these unquestionable proofs it would be but work of supererogation for us to follow further in the argument. It may reasonably be inferred that the centre of the earth is one mass of liquid fire, continuously in a state of incandescence, for, as we bore downwards from its surface, there is a regular and gradual augmentation which is assumed by analogy to increase in proportion to the depths arrived at; therefore it is plain, that at a given depth, as shown by the lavas, the temperature must be such as to reduce to fusion the most refractory constituents of the earth. But the question naturally arises—what is it that burns? Sir Humphrey Davy ascribed it to the chemical action of oxydable metals, as potassium, sodium, calcium, &c., which are supposed to exist in its centre; for it is familiar to all who have studied the elements of chemistry that water admitted to these metals in their simple state produce combustion. At the present time a nearly similar theory, having numerous adherents, prevails—amongst them many whose opinions are worthy of consideration. In a science which, though it early received attention, perhaps indirectly, from the teachings of the Indian and Egyptian schools of philosophy, under the nomenclature of cosmogony, to be afterwards improved upon by the speculative writings of the early Greek authors, as Strabo and his followers, still may be said to be in its infancy, and, with all its claims to antiquity, was but little understood at the commencement of the present century. Many of its leading features are yet undetermined, different views presenting themselves to its inquirers, according as such may be the most pleasing or natural interpretation; its evidences being altogether circumstantial, no positive proofs can therefore be arrived at, or possibly will such ever reach within the compass of man's knowledge; conclusions, therefore, must not be hastily drawn. We know there are many who hold that the solidifying of the earth began at its centre, and that volcanic action can be, without difficulty, traced to the contact of water with non-oxidised substances. Without venturing an opinion, we hesitate in pronouncing any as unerring, because at the present day all are more or less unstable; therefore, it becomes us to assume this is one of the many things our Creator has not yet permitted us to learn; so that conjecture is all that can be offered in the absence of data, upon which solid reasoning only can be based.

The Author's Concluding Note.

IN again issuing this book, now for the fourth time, each in still more revised form, and in arriving at its concluding pages, I have but to remark that geological study, although dating back for considerable time, has still but few determined rules from which reliable inference can be drawn; opinions too often in opposition prevail amongst authors, for it is extremely difficult, nay impossible, for man to arrive correctly at conclusions which, after all, can only be deduced from circumstantial evidences: with this prelude I have only to say that throughout the foregoing chapters I have endeavoured to decipher the great book, the Author of which is our Creator, the unfolding of the leaves of which, cumbrous and unwieldy though they be, as they have lain for unnumbered ages over each other as deposited strata, teach the wonderful history of the little speck in space which is the habitat of man. Let us return in thought for a moment to the period we imagine it was first launched into being. According to scientific notions, this earth of ours was once an igneous mass, and afterwards it became resolved into a cooled and irregular surface covered by water, here and there showing in its surroundings elevated shapeless masses and yawning chasms, until little by little the magnificent scheme of creation was evolved, an atmosphere was formed, the waters were gathered together, rain, snow, and ice followed, and the humble lichen, the first progenitor of vegetable life, stealthily appeared in incipient green a parasite upon the fire-moulded rocks; disintegration in its primary stages set in, and the great sculptor, water, commenced its work, shaping down and mellowing heterogenous masses into pleasing outline and picturesque form; countless tiny rills glittering like silver threads in the ebullition of their young day life coursed down the acclivities, uniting their pigmy forces, they formed into foaming, effervescing cataracts, which hurled away every obstruction in their paths, excavating deep chasms and abysses, through which still glide or rush onward to their ocean home, the undulating stream and the broad, impetuous river to be again restored to their pristine work, as rain continuing on thus for ever. Soon the various forms of fucoid life—the earlier mosses and ferns barely distinguishable in their verdant hue appeared—first as infinitesimal things, like their congeners, the lichens; at length the ferns attained enormous proportions and arborescent development, encompassed on all sides by giant reeds and gramineal plants, and forming seas of vegetation far and away surpassing their present representatives in tropical

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regions; next came the hardy, the ornamental, and useful trees, such as would adorn a sylvan scene, accompanied by all the contributaries to the support of animal life—the petrified remains of these once living created things, and the fossilised imprint of their most minute leaves still and will exist throughout all time in the strata which compose the leaves of our book, sedimentary rock; animal life was then called into existence, little by little, until it attained the enormous proportions of the *Elephas primigenius;* the woolly rhinoceros, the Irish elk, and the cave lion roaming in herds or solitary through primeval forests; and last of all appeared man, imaged to the likeness of his Maker and commanded to lord it over creation.

I have said above "the petrified remains of these once living created things exist," but nothing of the kind is really proved with regard to him who is the most perfect work of all. Fossils of fish, the mammals, and carnivora are numerous, but where is fossil man who existed contemporaneous with the far-off removed forms of animal life. 'Tis true, human bones are discovered in contiguity with extinct mammals, but grave doubts exist whether or not they were contemporaries, therefore proof does not follow from this. Waters have frequently inundated the caverns in which they are found, violently disturbing their contents and mixing together the *debris* of widely different periods in one heterogeneous mass. A few geologists insist upon fossil man, and I have already described the man of Mentone as one of the arguments in favour of their theory.

In the earlier part of the present century they used to adduce as an example a skeleton discovered in red sandstone rock, and exhibited over Europe as fossil, which in reality it was, and looking like an approach to human remains, but when shown at the Jardin des Plantes, Paris, the great French naturalist, Cuvier, upset the doctrine it was intended to promulgate by proving it to a certainty to be none other than a batrachian or gigantic frog. Professor Nicholson, in Manual of "Palæontology," while admitting that the remains of man are found in proximity to and associated with extinct mammals, does not recognise them as of older date than is given in the history of the creation. He says: "We have no means of calculating the lapse of time that must necessarily have taken place except by analogies and comparisons which are not infallible."

The skulls and bones of the larger apes have also been shown as the remains of man. A negro skeleton found embedded in a coral reef, West Indian Islands, was triumphantly put forward as a fossil, but the rapid growth of coral, known to everyone, at once dispelled its identity.

To those whose minds are not warped there can be no doubt whatever but that man's appearance upon this terrestrial scene is as we have been all taught to believe it, and as Holy Writ gives it in the simple narrative of the creation.

W. H.

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